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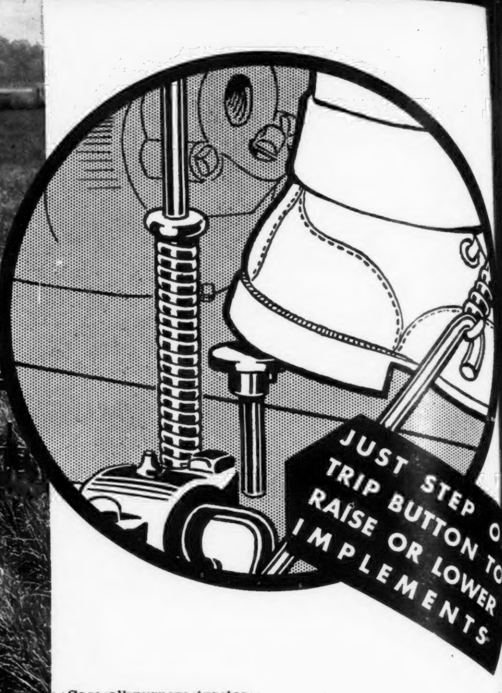

Case all-purpose tractor with narrow row Motor-Lift cultivator working onions in 12-inch rows.

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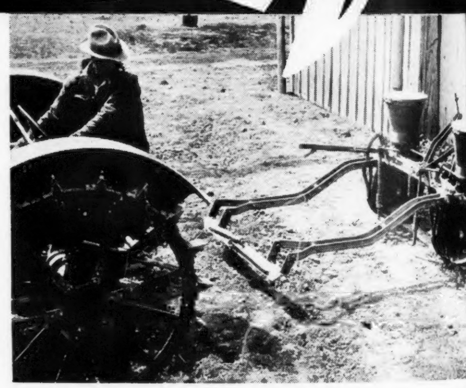

Here is the biggest all-purpose tractor development in years . . . one in which agricultural engineers as well as row-crow farmers will be especially interested. Never before has such easy, positive, step-on-a-pedal control of tractor-mounted implements been offered.

The Case Motor-Lift operates directly from the engine's power. Step on a foot pedal and up comes the implement. Trip the lift again and down it goes . . . with tractor traveling or standing. No hand levers to work. Both hands can be kept on the steering wheel. With fewer stops to make and less gear shifting, operator can do better work. The compactness and simplicity of this powerful worm and gear driven unit puts it years ahead of similar devices.

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CASE·77 *Modern* FARM MACHINES

AGRICULTURAL ENGINEERING

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VOLUME 16 FEBRUARY 1935 NUMBER 2

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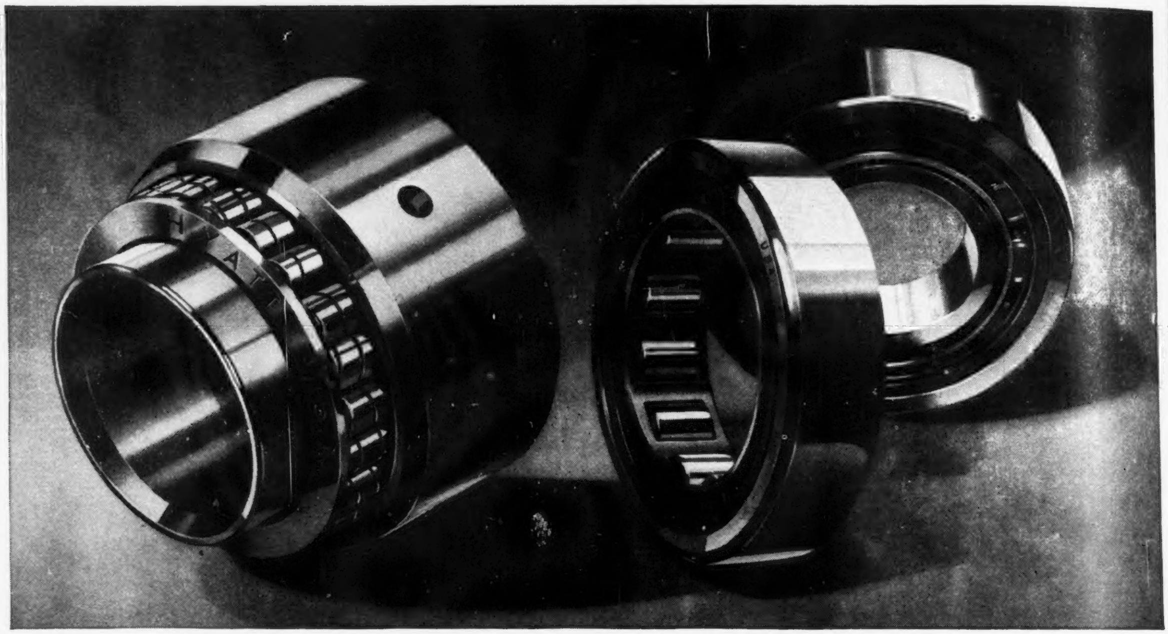

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AGRICULTURAL ENGINEERING

VOL 16, NO 2 — EDITORIALS — FEBRUARY 1935

The Farm Survey on Rubber Tires

THE RUBBER-TIRE questionnaire, sent out by the ASAE wheel-equipment committee and forming the basis for the committee's report compiled by Prof. C. W. Smith as published in this issue, has been criticised in ways that may be borne in mind when reading it. Although effort was made to avoid leading questions, the mere mention of subject matter is bound to be more or less suggestive of answers. It is argued, too, that on some points the farmers, having no records or adequate basis for estimate, have reflected perhaps unconsciously, the published experience of others or the claims made in advertising.

It also seems likely that these early users of rubber tires are largely farmers whose conditions are especially favorable to rubber, or in which other types of traction show marked disadvantage, and hence give no true perspective on the extent to which rubber tires are desirable in the whole of American agriculture. Nor must the human tendency to defend one's own judgment be overlooked.

No such criticism can be raised against the demand by numbers of these farmers for standardized wheels and tires interchangeable on various machines. Such interchangeability is not mentioned among the questions, embodied in machines available, nor featured in advertising. While proposed in these columns a year ago, we doubt if it has appeared much, if any, in farmers' reading. As it appears in the reported replies, it seems original and spontaneous.

In some of these replies, brief and hasty though most of them were, interchangeability has been definitely joined to the issue of economic desirability. Of course, any rational program of standard, interchangeable wheels implies a forbidding amount of redesign, but that seems to be the program toward which the farmers point.

The whole complicated problem of adequate traction under heavy pull or slippery footing is brought inferentially into review by the farmer who said that it takes a high hitch to make rubber tires pull. Certainly any escape from wheel weighting would seem welcome. Despite the grief that may arise from "trick" hitches, we suspect there is room to study the possibilities of weight transfer from load to tractor in the case of heavy machines, and of designing light-weight, heavy-draft implements to utilize the vertical component of the hitch angle to a greater extent than has heretofore seemed consistent with satisfactory operation.

While too much detail cannot be expected in a general questionnaire, it is unfortunate that this study affords no clear correlation between soil type and the various aspects of tire performance. We have repeatedly proposed that this be done from the research angle, and we now suggest that it be attempted in any future survey of farm experience and opinion.

Indirect Labor, A Key to Recovery

AMONG many laudable principles and objectives set forth in the presidential message to the current Congress at its opening, there stands out one proposal which runs counter to what we believe the convictions of agricultural and other engineers. We refer to the mention of direct labor as a desideratum in a program of public works intended largely to alleviate unemployment.

After more than four years of what we have called a depression, and all the expedients we have tried in the hope of ending it, the one place where the greatest unemployment and business stagnation persists is the group of capital goods industries and their tributaries. More than ever is the consensus clear that activity in these industries and their related services is the one thing needed to restore economic balance and normal employment. It will not restore economic balance nor *normal* employment to take idle workers from these skilled trades and set them at common labor. To put an expert artisan to drudging toil at such meager wage as it is worth is only a little better than keeping him on a dole. It is scant help to his morale, to his purchasing power, or to the taxpayer.

Far from harmonizing with objectives of the New Deal, such as enhancing the welfare of the whole people both as workers and consumers, utilizing more efficiently our national resources, etc., the doctrine of direct labor is a look backward toward the methods whereby, presumably, the Egyptian pyramids were built. It is inconceivable that our national leadership makes such proposal of its own volition or judgment.

In the very fact of leadership, as contrasted with the willy-nilly driving power of dictatorship, lies the probable explanation of this paradox. Leadership can proceed only so far and so fast as there are followers who can keep up—or at least keep in sight. No doubt the doctrine of direct labor is a shrewd and perhaps necessary concession to the widespread delusion that the machine is enemy to labor. Our logical course, therefore, is not to criticise the president, but to dispel the delusion and thereby free him from misguided popular and political pressure.

Substantial data to this end were presented at the ASAE annual meeting last June, and appeared in these pages in July. To serve our president, our unemployed, and our country, their import must be made known beyond our own publication and our own profession. Simple as it all seems to engineers, it must somehow be thrust into the consciousness of the man in the street—too often our "forgotten man."

Admittedly only 85 per cent, more or less, of expenditures for machinery (at least of the sort we know best) reappears as wages, but 85 cents of a recovery dollar reaching the particular labor which is the crux of our unemployment and business problem is far better than to make 100

cents reach the same or other labor in a fashion which leaves the causative condition untouched. It is better to solve our problem with 85 per cent efficiency than to prolong it at apparently 100 per cent, but really zero per cent, efficiency.

The president's own phrase, direct labor, tacitly concedes our contention. It implies the companion phrase, indirect labor. If not an actual invitation, at least it challenges those who know whereof they speak to sound the merits of indirect labor.

Outlets: For Terraces and for Labor

HOW ENGINEERED correlation of hand labor with optimum use of power machinery creates rather than destroys self-respecting employment, and at the same time enhances the amount and quality of work accomplished, is reflected by Mr. Leonard J. Fletcher (past-president of ASAE) in a comment on terracing as it has been discussed in these columns. Closely connected with the development and application of terracing machinery, he emphasizes its need for complementary labor in this wise:

"In the use of hand labor in terracing, there is without doubt one of the most effective combinations of employing hand labor with machinery power that has been developed in the entire federal employment or relief program. Building terrace outlets is, to a large extent, a hand job. Men have no objection to doing a job by hand when the work is legitimately hand work and they are not simply displacing a mule or a tractor.

"Where men are employed in the terracing program to build good outlets, they are doing work which is vitally necessary to the success of the whole erosion control project. The heavy job of moving the soil into the terrace ridge is done with mechanical power. In fact, this splendid coordination between the legitimate use of hand labor and mechanical power in the many terracing programs being organized in various ways over the country, is a real achievement and something to be used as a pattern to copy rather than as a target to shoot at."

Soil Erosion Control Is Engineering

THE REPEATED admonitions of Past-President Arthur Huntington to our profession that we accept the social responsibility created by our special knowledge, that we and all engineers be not cringing hirelings but leaders speaking boldly whereof we know, come to concrete application in soil erosion control. In many phases of our work we accept our premises and objectives from the agronomist, the animal husbandman, or other agricultural scientist, and fill in an engineering technique. The ability and willingness of our profession in such cooperative or subordinate work are in the record.

In soil erosion control the situation is reversed. In various of its aspects we have invaluable contributions from other specialists, all of which we gladly acknowledge, and each of which we use to the optimum extent. But as an overall practical problem, only the engineer has adequate grasp of all technical and economic considerations. This is so well put by an erosion-control veteran that, without permission and hence without citation, we make his words our own. He has said.

"Satisfactory solution of any erosion control problem depends on a knowledge of cost, effectiveness, and practicality of the various erosion control measures employed, and a carefully balanced relation of these three factors. This is essentially an engineering problem regardless of the nature of the control measures employed.

"The problems involved in all methods of erosion control require a knowledge of rainfall, run-off, percolation, and an intimate knowledge of hydraulics as it pertains to the flow of water in drainage channels, such as terrace channels and outlet ditches, and also the flow over the ground surface as modified by various roughness conditions of the ground surface and of the vegetative cover.

"The engineer receives special training and education in the foregoing subjects which particularly fit him for dealing with all methods employed in soil erosion control. He must, however, depend upon the agronomist for a knowledge of crops and other vegetation best adapted to any particular locality and soil, together with information relating to cropping practices; upon the soil scientist for a knowledge of the physical properties and fertility of different types of soil; and upon the forester for information relating to tree varieties and their adaptability to any particular locality. He must know that all methods of erosion control are not equally effective during all seasons of the year, particularly those involving the use of vegetation, and that the rains of highest intensities often occur at seasons of the year when the ground is not protected by these methods.

"With this information the engineer is prepared to determine with a considerable degree of precision the part that the various practices of erosion control, involving the use of vegetation, timber, tillage methods, and terraces, should play in a comprehensive and harmonious plan designed to control the run-off water and thereby soil erosion most effectively."

In anything so vast and vital as America's soil resources and their protection there should be no guesswork or indulgence of theories. Proven principles reduced to accurate quantitative formulas and fortified by seasoned judgment are the only sound basis for full-scale operations.

Quantitative precision is so ingrained in the engineer as to be almost instinctive. He it is who devised ways to measure amount and rate of run-off, who contrived means to determine both light and heavy soil therein, and who correlated the factors of season, slope, soil, crops and their rotations, tillage practices, etc. It seems obvious that he who has defined most exactly the conditions to be met is most competent to prescribe an effective and economic combination of treatments.

Nor is the human element to be ignored. By long experience the agricultural engineer knows what the farmer can be taught or persuaded to do; what methods of erosion control are more likely to be consistently maintained and which are liable to disastrous lapses. So, too, does the record of the agricultural engineer give him a unique place in the confidence of farmers. His long and successful service to practical agriculture has given him an authority not to be lightly tossed aside.

A Study of Users' Experiences with Rubber-Tired Farm Tractors[1]

Summarized and Reported by C. W. Smith[2]

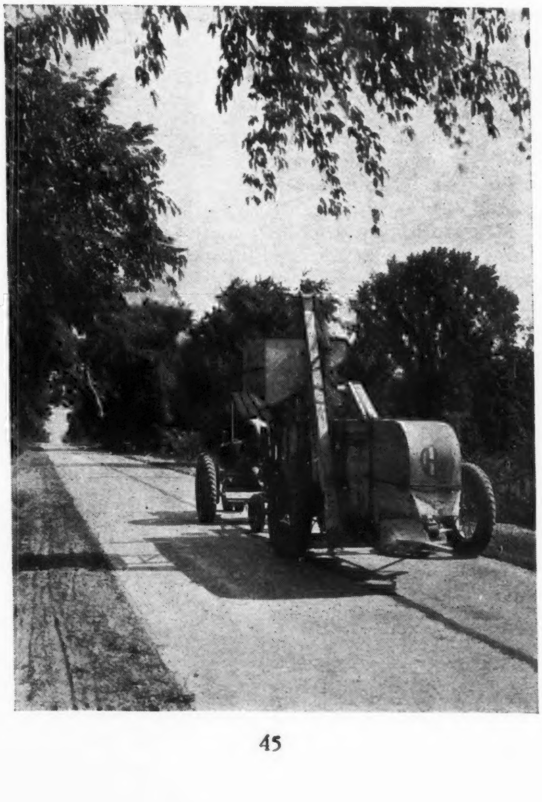
THE COMMITTEE on Agricultural Wheel Equipment of the American Society of Agricultural Engineers made as one of its major activities for the year 1934 a study of pneumatic tires for tractors by means of a questionnaire sent to users. Beginning October 15, 1934, 3000 questionnaires were mailed to tractor owners who had purchased rubber tires. The mailing list was made up from names and addresses furnished by tire and tractor manufacturers, of men who had purchased pneumatic tires for tractors. The questionnaires as returned were summarized by Mr. Smith of the Committee. A preliminary report covering 373 replies was made at the meeting of the Power and Machinery Division of the Society at Chicago last December. This final report, however, is based on 686 replies, that is, all those received prior to January 1, 1935.

It is recognized that this questionnaire was filled out, by those replying, at the close of 1934, the driest season in the history of our country. The preceding season, 1933, was in general one of scant rainfall. Pneumatic tires on tractors being a recent innovation, experience with them has been confined largely to these two seasons. Where the Committee takes pride in this contribution to the information on pneumatic tires for tractors, it also recognizes its limitations and in the spirit of true research feels that all will live and learn.

A copy of the questionnaire mailed out is appended to this report.

For the purpose of summarizing, 74 headings were used many of which were grouped in the final analysis. The sequence of topics and questions in the questionnaire is adhered to for the most part, as an outline for this report.

Table 1 and Fig. 1 show the sources by states of the 686 replies, with the exception of a few who failed to give their addresses. Where one owner reported more than one tractor on rubber, the same was shown on the map, not by two or more dots but by one dot and a figure giving the number of tractors on rubber. Replies were received from most states.



The total number of tractors reported both on steel wheels and rubber tires was 1,604. The number on rubber tires was 948. Those rubber-tired tractors represented 16 different makes and 42 different models. The average time that the rubber tires had been in service was 7.06 months. 51.9 per cent of the rubber tires had been bought on new tractors; 48.1 per cent equipped old tractors with new tires.

Fig. 2 gives the classification of replies by sizes of farms. It is of interest to note that the majority of these replies comes from farms of a very common size; in other words, they are not from freak situations. The smallest size reported was 4 acres; the largest, 16,000 acres. More replies were received from farms ranging in size from 160 to 320 acres than from any other group.

Rubber-tired tractors were reported used on 54 different operations; 33 of the more important are shown graphically in Fig. 3. They are divided into drawbar work and belt work. As would be expected, the drawbar work is much more significant. Belt work in addition to the drawbar work shows the possibility of a greater utilization of the tractor.

A large number of descriptive terms were used by the various men reporting to designate soils. The most significant of these have been used in Fig. 4 to give a picture of the relative importance of the various terms, so far as this report is concerned. An effort was made to correlate dissatisfied owners with soil types, also to show the relative importance of topography. There were too few dissatisfied replies when distributed among the various soil types to make this phase of the graph have much meaning. For example, there is not sufficient evidence to say that users of rubber-tired tractors on clay soils are generally dissatisfied and owners on sandy soils are generally satisfied.

Tractors were used all the way from 70 hr to 2,550 hr and above per year. Fig. 5 shows the distribution of these replies according to the hours the tractor was used annually. In making estimates, men are inclined to use such generalizations as 500, 1000, and 1500. Note how these stand out on the graph. It would seem apparent that too few use the tractor enough hours to approach its most efficient utilization.

There were 231, or 33.7 per cent who reported that

[1]Report presented at a meeting of the Power and Machinery Division of the American Society of Agricultural Engineers at Chicago, December 3 and 4, 1934, as a contribution of the ASAE Committee on Agricultural Wheel Equipment—H. W. Delzell (chairman), J. W. Shields, R. W. Sohl, B. G. VanZee, Dent Parrett, E. E. Einfeldt, R. U. Blasingame, B. D. Moses, M. L. Nichols, and C. W. Smith.

[2]Department of agricultural engineering, University of Nebraska. Mem. ASAE.

TABLE 1. DISTRIBUTION OF RUBBER-TIRED TRACTORS BY STATES

State	All tractors	Tractors on rubber	Number of returned question-naires	State	All tractors	Tractors on rubber	Number of returned question-naires
Alabama				Nebraska	61	41	41
Arizona	13	7	5	Nevada			
Arkansas	3	3	2	New Hampshire	4	3	3
California	80	55	41	New Jersey	2	2	2
Colorado	21	15	11	New Mexico			
Connecticut	27	18	16	New York	56	23	24
Delaware	2	1	1	North Carolina	17	13	10
Florida	63	47	24	North Dakota	30	19	21
Georgia	18	12	7	Ohio	67	36	27
Idaho	10	9	9	Oklahoma	156	119	23
Illinois	264	66	40	Oregon	6	5	6
Indiana	107	77	67	Pennsylvania	76	35	30
Iowa	55	34	32	Rhode Island	4	3	2
Kansas	39	27	28	South Carolina	14	11	9
Kentucky				South Dakota	15	9	9
Louisiana	12	8	4	Tennessee	5	2	2
Maine	11	6	6	Texas	82	51	31
Maryland	9	5	5	Utah	4	4	4
Massachusetts	29	25	15	Vermont	2	2	1
Michigan	30	19	19	Virginia	14	8	8
Minnesota	42	26	25	Washington	8	8	5
Mississippi	13	6	3	West Virginia	1	1	1
Missouri	16	8	8	Wisconsin	28	20	16
Montana	10	6	6	Wyoming			
Address not given	78	53	34	No information			3
				Total	1604	948	686

they used their tractors for hauling; 111 gave the number of hours per year the tractor was used for hauling, which when averaged was 165 hr. This was in addition to the hours used for other work. From the replies one company was omitted. This company had 98 tractors on pneumatic tires and used them 1,000 hr per year for hauling, which was considered an unusual case and one that should not be averaged.

There were 328, or 47.8 per cent who reported doing custom work, and they used their tractors an average of 277 hr per year for this work.

A total of 468 reported that they used their tractors more since having them equipped with rubber tires; 272 reported that they did not use them more.

Nearly 100 per cent of those reporting reported a fuel saving; the average of the figures given, and there were 451 who gave figures, was 24.8 per cent. The figures reported ranged all the way from 0 to 50 per cent.

In answering the question, "How much more work can you do in a day with rubber tires?", the answers ranged from 0 to 100 per cent. 462 replied, giving estimates. An average of these gave 25.2 per cent more work with rubber tires.

"Have tires reduced breakage and repairs? How much?"

346 answered "Yes;" tires had reduced breakage and repairs

43 answered "No;" tires had not reduced breakage and repairs

33 questioned whether they had or not

2 said breakage and repairs had been increased.

There were 129 who gave figures as their estimates of the saving in breakage and repairs. These estimates ranged from 100 per cent saving to 50 per cent more repair. When averaged, they show a saving of 39.3 per cent.

"Do you operate tractor in higher gear with rubber tires?" 555 answered "Yes;" 54 answered "No." A few of these replies were qualified and such answers were classified either as "Yes" or "No" according to the main intent of the answers.

FIG. 1 DISTRIBUTION OF RUBBER-TIRED TRACTORS BY STATES. WHERE ONE MAN OWNED MORE THAN ONE TRACTOR, IT IS INDICATED BY A FIGURE AND ONE DOT

"Do the tires gives satisfactory traction?" 656 said "Yes;" 13 said "No." A few qualified their answers but the number was too small to be significant. If they seemed satisfied, it was considered as "Yes." If dissatisfied, "No."

"Do you have trouble with tires slipping in mud?" Out of 625 replies, 403 answered "Yes;" 70 answered "No;" 39 said they did not use them in mud; 6 had had no experience in mud; 53 said "Some."

"Do you ever use chains? Under what conditions?" 514 said "No." 138 said "Yes," among which replies were 43 who said "In mud;" 58 said "When wet;" and 10 who said "When plowing." Other reasons given for using chains were: soft on top, all conditions, ice, low gear, frost, disking, and sod.

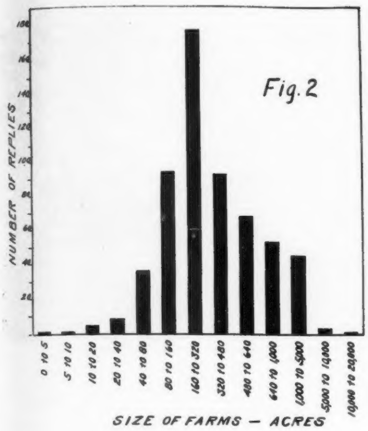
"How many weights per wheel do you use?"

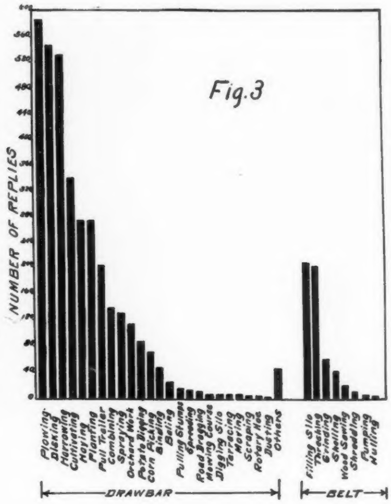
Number of weights used per wheel	Number using them
0	192
1	150
2	254
3	65
4	7
Total replying	668

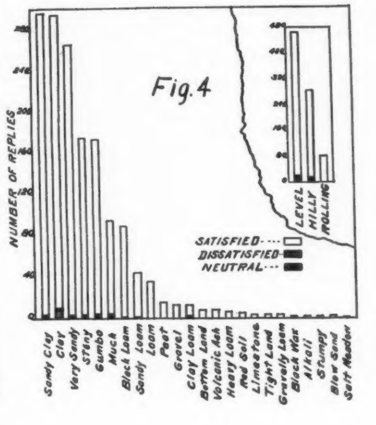
"Have you had any punctures or flat tires? If so, how caused?" 442 had not; 242 had. The causes given for punctures were:

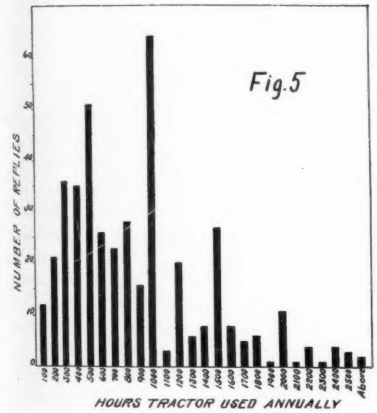
Nails, spikes, staples, etc	94
Thorns	33
Snags, splinters, roots, etc.	21
Valve	16
Defective tube	9
Wire	7
Cornstalk stubble	6
Pinched tube	4
Low pressure	3
Stone	3
Pitchfork	3
Weed stubble	2
Cultivator and harrow teeth	2
Glass	2
Slipping on rim	2
Rake tooth	1
File	1
Furrow side wall	1
Belt rubbing tire	1
Cut bv disk, etc.	1
Cotton stalk	1
Valve cap inside	1

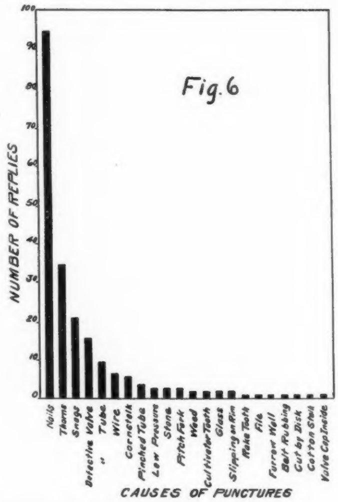
This is shown graphically in Fig. 6.

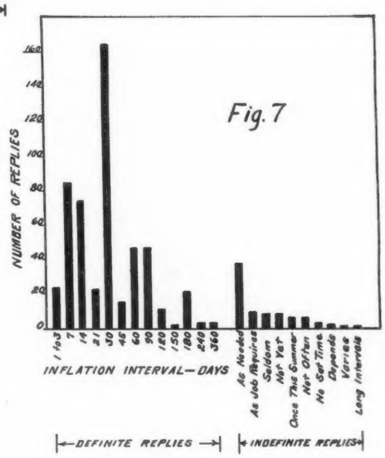


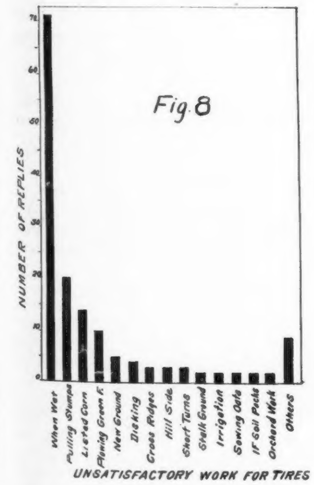


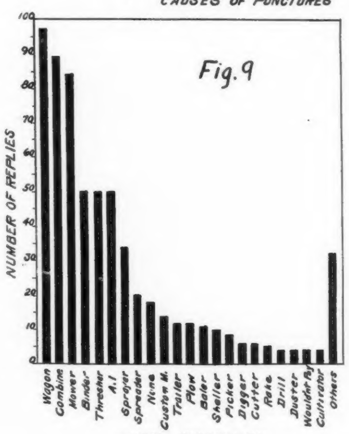












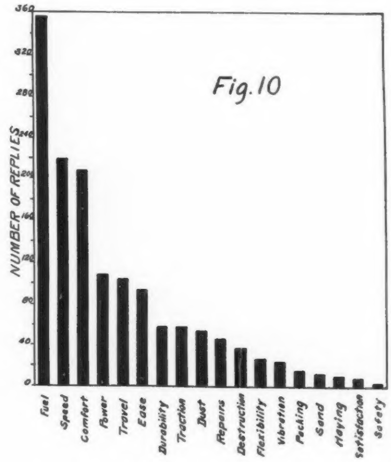


FIG. 2 CLASSIFICATION OF REPLIES BY SIZE OF FARMS. FIG. 3 CLASSIFICATION OF REPLIES ACCORDING TO KINDS OF WORK WITH RUBBER-TIRED TRACTOR. FIG. 4 CLASSIFICATION OF REPLIES ACCORDING TO TYPES OF SOILS. FIG. 5 CLASSIFICATION OF REPLIES BY HOURS TRACTOR IS USED ANNUALLY. FIG. 6 CLASSIFICATION OF REPLIES REPORTING PUNCTURES. FIG. 7 CLASSIFICATION OF REPLIES BY INFLATION INTERVALS. FIG. 8 CLASSIFICATION OF REPLIES WHICH SPECIFIED SOME WORK FOR WHICH TIRES ARE SATISFACTORY. FIG. 9 CLASSIFICATION OF REPLIES ACCORDING TO MACHINES THAT SHOULD HAVE RUBBER TIRES. FIG. 10 CLASSIFICATION OF REPLIES ACCORDING TO REASONS GIVEN TO JUSTIFY BUYING RUBBER TIRES

"How often do you inflate tires?" 601 replied to this question and it was thought best to show their answers by means of a graph (See Fig. 7). It would be instructive to follow these tires through their entire life, to see if there is not some correlation between length of life and frequency of inflation. Fig. 7 is certainly suggestive.

"Do tires ride easier?" 640 said they did. 2 said they did not. 25 said they did on the road but not in the field. 2 were doubtful. 1 said "Not always," and one said "Very little."

"Do rubber tires pack the soil more than steel wheels?" 77 said "Yes;" 540 said "No." 3 said "Yes, when wet." 4 said "Yes, on the surface, not below." 4 said "Very little." 6 said "Very little difference." 3 said "It depends." 1 said "Possibly." 1 did not know.

"Are tires satisfactory for belt work?" 464 said "Yes." 7 said "No." Other replies regarding the use of a rubber-tired tractor for belt work were: 5 said "Hard to block;" 12 said "Hard to keep belt tight;" 2 said "Electric shocks;" 5 said "Jerks around too much;" 1 said "Not enough clearance;" 1 said "Too much jiggle;" 1 said "Hard to line up;" 1 said "Too much spring."

"Do you have any work for which rubber tires are not satisfactory?" 14 said "Yes," but gave no explanation. 441 said "No." Fig.8 shows the remainder who not only said they had work for which the rubber-tired tractor was not satisfactory but described it. *Wet conditions* stand out in this figure.

"What farm machines other than tractors do you think would be more satisfactory if equipped with rubber tires?" Fig. 9 gives a classification of the replies according to the various farm machines suggested. The wagon leads, 97 having named it; 89 named the combine, and 84 the mower. This chart indicates the need of pneumatic tires on harvesting machinery as a class. It also would seem to indicate that in the minds of farmers there is not so much need for tires on tillage implements such as the plow, lister, cultivator, rotary hoe, etc.

"If buying a new tractor would you want it equipped with rubber tires?" 620 said "Yes." 15 said "No." Others qualified their answers as follows: 7 said "Depends;" 3 said "Some with, some without;" 3 said "Questionable;" 3 said "Not more than one;" 3 said "Farm work no, road work yes;" 2 said "If only one, no;" 1 said "Probably;" 1 said "Small tractor;" and 1 said "In front, yes."

"Do you feel justified in having gone to the expense of buying rubber tires? If so, what are your most important reasons?" Fig. 10 gives a classification of the replies according to the reasons given in justification of buying rubber tires. In studying over the remarks given by many, we find other reasons than those listed in answer to this direct question. However, this tabulation is made up from answers given directly in answer to this question and does not have those additional reasons found under "Remarks," incorporated. The reasons were tabulated under 18 headings. The headings are given and a brief explanation or typical replies after them, as follows:

Fuel—Save fuel.
Speed—Do more work.
Comfort—Easier riding, health, etc.
Power—Has more power.
Travel—Can drive on roads, from farm to farm, from field to field, etc.
Ease—Easier on tractor and machines.
Durability—Longer life of tractor, less wear, etc.
Traction—Pull heavier loads, more drawbar pull.
Dust—Wheels throw less dust about driver and machine.
Repairs—Lessen repairs.

Destruction—Do not injure fruit trees and fruit tree roots.
Flexibility—Can do more kinds of work.
Vibration—Less vibration.
Packing—Pack soil less than steel wheels.
Sand—Give better traction in sand; do not dig in.
Haying—Mowing, sweeping, etc.
Satisfaction—Better quality of work.
Safety—Less danger wheels catching man's clothing, etc.

"THE OWNERS' VOICE"

Reading the comments on the returned questionnaires given under the heading "Remarks" was much like the experience of going to an old-fashioned testimonial meeting. The number of such comments favoring rubber tires was very much greater than the number condemning them in whole or in part. Naturally, with so many giving favorable comments, there was much repetition of such points as easier riding, save fuel, do work faster, throw less dust, etc. A very large number referred to the beneficial effect of the use of rubber tires on the health of the operator. In compiling this portion of the report, it has been the aim to include all ideas expressed in as nearly the language of those answering the questionnaires as possible, and yet avoid undue repetition of the same thought. This procedure has thrown out a vastly greater number of favorable comments than of negative comments, and those quotations given should be read with that in mind. The selected comments follow:

"Have been farming with tractors for many years. I feel rubber tires have helped more than anything that has been brought out lately . . . . ."

" . . . . Using cattle guards instead of gates . . . ."

"Make tires so they can be changed from one machine to another . . . . . We have 17 rubber tires on this farm: three-plow tractor, 4 tires; trailer, 4 tires; car, 5 tires; ensilage cutter, 4 tires."

"We find much less dust on air cleaner since using tires."

" . . . . Would suggest that many of our tools be designed to take a standard size wheel, permitting changes from one tool to another, as most tools are used too few hours to justify the investment in tires for each machine."

"It is impossible to keep from bouncing. In the field, steel wheels ride easiest, but steer some harder. In both extremes of wet and dry, traction is poor, and with listed corn using four-row go-dig, it is impossible to keep tractor on ridges. On plowed soil, in most cases, think rubber tires are absolutely satisfactory but too expensive for satisfaction received and saving made."

"In two seasons' use, the tires do not show any wear to speak of."

"Differential and transmission repairs were, up to the time of the rubber tire equipment, of considerable regularity. This expense and delay have been practically eliminated. . . ."

"The best thing about rubber tires is that they do not raise up so much dirt for binders and combines to run in. . . . ."

"Rubber-tired tractor is great for packing silage in a trench."

" . . . . My wife says she would not drive any other but rubber tires."

"I have crossed creek at intervals and find it difficult to pull up the bank in getting out with tires wet and bank muddy . . . ."

"My reasons for buying rubber for this machine are probably different than most buyers. I have a contract to roll an airport of 150 acres twice each spring with a five-ton trailing roller. Regular cleated wheels ruin the turf. Smooth-faced steel wheels with golf course spikes do not give enough traction for pulling a five-ton roller. Rubber handles this job perfectly in high gear. I do practically all my farm work with track-type tractors, taking care of small custom jobs of plowing, harrowing, etc. with the rubber-tired machine on account of its easy mobility from one farm to another. If I were buying a tractor for all around farm work and could only own one machine, I doubt if I would buy rubber tires. Around these parts they cannot handle spring plowing even with chains."

"Our work is all in six-foot rows, and we use a wide-tread tractor. In making this row we have a row plow with a 16-in lister in the front, two 10-in side plows, and one 10-in lister in the rear. In breaking this land out, which is sandy, we tried it with steel wheels and lugs. The tractor would dig down and bury itself. We immediately changed to rubber tires and we got right on through, with no trouble. Another thing we are doing, pulling two trailers equipped with the same tire, interchangeable with the tractor, hauling sugar cane a distance of 18 miles one way for 37⅛ cents per ton, including the entire expense. This tractor makes 18 miles per hour and is capable of hauling six tons at a trip."

" . . . . Weights on wheels should be made to enable the use of a log chain around the tire and wheel rim in an emergency."

"I have found tires excellent except when plowing under green crops. While doing this, the tires squeeze the moisture, or sap, out of the plant. This makes it sleek so the tires spin. I consider this a very great handicap to using tires . . . ."

"Rubber tires are no good in mud. They won't pull the hat off your head in mud. However, a set of extra heavy chains will entirely overcome this. We are now using our tractor to pull a 16-ft cut combine (weighing 9,000 lb) over soft fields and keep the chains on all the time. This makes a big load when you get another 3,000 lb in beans. *Every tractor should be sold with chains.* Farmers dislike very much to spend $30.00 extra for the chains, but it would not be noticed if part of the purchase price . . ."

"Do I like rubber tires? There is no comparison between rubber tires and iron wheels. I figure my health the most important factor as I could not ride my other tractor more than three days at one time. In deep sand they increase the power 50 per cent. Rubber tires do not shake as iron and also get away from that awful dust storm that follows steel wheels. Tractor needs a foot brake with rubber tire equipment."

"Rubber tires make the tractor three times more useful than with steel lugs. Where before we would use horses on account of the lugs tearing up the ground, now we use the tractor and requires about half the time as before."

"Rubber tires save my barnyards from being all cut up. Can drive tractor on barn driveways, across scales, and on grass or lawn without damage. I find that when I cut my grain crops, when I have some clover in them, rubber tires do not destroy any little clover as did my steel wheels. I have hills that are sandy; could not pull over with steel wheels; with rubber tires I go right over. I have cultivated corn, hills of corn 6 in high, that were run over with low-pressure tires will straighten up without damage."

"We think that rubber tires will save one-half the expense and do more and better work in every way."

"For the average farmer, rubber tires are a waste of money. For the estate owner they are ideal as they do not dig up the roads."

"I load my tractor on a truck by the use of two oak planks. It loads very easy and with steel wheels there is the job of removing the lugs. A man works with a rubber-tired tractor the equivalent to three days work, is less tired than with steel wheels one day. It is the only tool for haying for several reasons. I have done all of my farm work without a horse on the place."

"In regard to breakage and repairs, we believe the cushioning effect of tires will reduce breakage considerably, especially in stony soil. In case of hard, slippery surface, steel wheels with lugs will pull more than tires without chains, but in sticky mud or where lugs fill up, it seems that tires even without chains will give more satisfactory traction. We have been using these tires since May 1933. In buying a new tractor equipped with tires, it seems one must pay for both sets of wheels, where it would be to the advantage of the manufacturer to put his tractor out on rubber tires. The point should be worth their consideration."

"If for any reason I could not have tires on all four wheels, I would at least have them on the front wheels. Steering is much easier. Rubber cannot be beat for road dragging. Rubber will give more traction with no slippage."

"I picked corn with my rubber-tired two-row picker this fall and find one greasing will last half a day as there is no dust, and same goes for my ten-foot grain binder. I use my tractor year around as I have no horses, that I can now do with my rubber tires."

"Tractor handles easier and leaves ground in better shape, this especially true of corrugated hay land where irrigation is done in corrugates."

"The first year they did not need inflation at all, but the second year or now they don't seem to hold their pressure very good."

"I am sure that the tread on tires should be heavier and deeper as tractor doesn't pull as well when tread gets worn off. I wouldn't think of trying to farm without rubber on my tractor . . . ."

"I find that they have about the same amount of traction on all kinds of soil. I pull a thresher about 250 miles a year over all kinds of roads. I ford rivers and pull through sandy fields. I had two old wheels bolted on the outside of the tractor wheels for three years but they didn't give as much traction as the rubber does on sand and gravel. They slipped on the hills about half and I would have to go to low gear. The rubber doesn't slip and I go up the same hills in second gear."

"Our farm is located on oil-dressed road. We were forbidden to use the tractor or drive it along this road with the steel wheels. Consequently, we bought rubber tires and have been satisfied with the compulsory change. We can go anywhere on the road now. without harming it. We have hauled a great deal of hay with the tractor after we equipped it with rubber tires but we could not before because, if we used the regular heavy lugs, we pushed the hay into the ground, and if we used the hay cleats, there was not traction enough to pull any load, but rubber tires overcame all this."

"For plowing we use three weights on land wheel and one on furrow wheel. We move our tractor between farms by towing behind a car or truck at a speed of 25 to 35 miles per hour."

" . . . . No jerking on steering wheel. Tractor can be rolled by hand to machinery. Tractor can be pulled by auto or truck a distance for work at any speed you care to drive and does not pull any harder than an auto."

"I find my tractor steers harder, that is, it takes more power to turn the steering wheel. Some changes should be made in the steering gear."

"I think that most all farm machines in time will be equipped with either hard or pneumatic tires. It would not be long if a system was worked out whereby pneumatic tires and wheels were changeable with other machines. By having an extra set of fore wheels and tires the same as the front wheels on my tractor, they could be used on wagon, mower, manure spreader, binder (grain or corn), sprayers, plows and others that are only used for a short time each season."

"Cultivating machinery used in leveling and grading when season is over. Under conditions with 130 hours' work in two weeks, tread apparently wears down in approximately six months. It depends on the life of the remaining smooth rubber as to whether tires, as we have use for them, will prove economical."

"I found out that the drawbar wants to be up as high as possible to get the traction, and I ought to have heavier wheel weights . ."

"We have had remarkable results with rubber traction. Could cut hay in places where it was impossible for the steel wheels to go. Reduced breakage to a minimum, taking almost all the jar; tractor moves easily with but the use of only one-half the power it has, and a great help on the boys operating them, which, with us, on the rough meadows, was rather a serious problem with the hard steel wheels. I am giving results only with the native, wild hay cutting and we do not farm at all. On the report of extra time saved—days work—I base my conclusions from the time we spend being stalled in places, both soft and sandy, with the steel wheels. In past years this has been very discouraging. This one thing, if nothing more, will pay us for our investment in operating a big outfit . . . ."

" . . . . A particular advantage of rubber is that if tractor encounters overload, rubber will spin on surface, while lugs will dig in, and in orchard work injure tree roots . . ."

" . . . This one will handle a two-bottom plow very nicely, but if plowing, listing and one-waying were all I wished of a tractor, I would not buy a rubber-tired one."

" . . . Have an accurate account of fuel and oil used and it won't take very long to pay for the tires, say nothing about lengthening the life of the tractor and the man. No man can ride a lug tractor in the heat and dirt and live very long . . ."

" . . . Employees like to use them . . . keeps them contented . . . . They do not shake the guts out of the engine or the driver . . . ."

"In all field work for the past year with a load that usually required low gear with steel wheels, the tractor with rubber tires pulls the same load and under same conditions, a greater load in high gear with far less effort on the part of the engine. Since on the rubber tires we have met no conditions to justify putting on our steel wheels."

" . . . Before two 10-hour days would make me a nervous wreck but now I drive it myself and keep just two horses."

" . . . In order to get rubber tires for the front I had to get 9.00x36 for the rear, which gave me a gain in speed of nearly one mile per hour or an increase of one-third and the tractor had much more power, so I have checked it pretty close that in a ten-hour day I can do more work with one-third less fuel. I save about $1.50 per day, or 15 cents per hour since I got my tires . ."

"In belt work I use a plank and block, laying one end of plank on front wheel. By laying block on plank it will slide down as you back."

"The tires should have a heavier tread to give them a little more traction and wear."

"Rubber tires stand sidedraft better than lug wheels. I pull my terracing machine and have no trouble staying where it belongs. (I removed front wheel on terrace machine) and have plenty power and speed which are essential to building good terraces."

"Perhaps weights on wheels would help under many conditions, but I think a good set of chains would help more. They would more than pay for themselves by reducing slippage."

"It gives it more power and speed and it is much better on the road and it has it over all other steel tractors after a rain. You can go out and cultivate when others can't. Just let out a little air, and the mud won't ball up."

"I have one of the new . . tractors, equipped with 12¾x28 in on rear and 6½ in in front. The cost of wheels and tires was $370.00, and cost of tractor was $1000.00. This tractor was paid for in cash money. Our sole business is selling milk to a creamery for $1.50 per hundred. This is the only job out in service in . . . . I reckon we paid for our experience, so let the Big Guy do the same."

" . . . Very lumpy ground, was not so good on hard pull because lumps will roll with tires. Tires will not crush lumps. . . In cutting or raking hay will not damage the new growing hay. Does not push the cut hay in the ground. Hay or corn stubble is damaging to tires. Well satisfied."

"All I can say is I sure would hate to part with them."

"One tractor of each type of wheels would be more economical if a farmer had two tractors. If he had only one, it would not be advisable to get it with rubber tires because in combining it might be a wet year and the same in cultivating through wet draws."

"I believe with the use of rubber tires one could mount a sprayer to the tractor for spraying potatoes, whereas with the lug type the jolt and jar would cause too much breakage. . . ."

"I have found rubber tires not so good in plowed ground. When buying a new tractor would get open wheels and also the rubber."

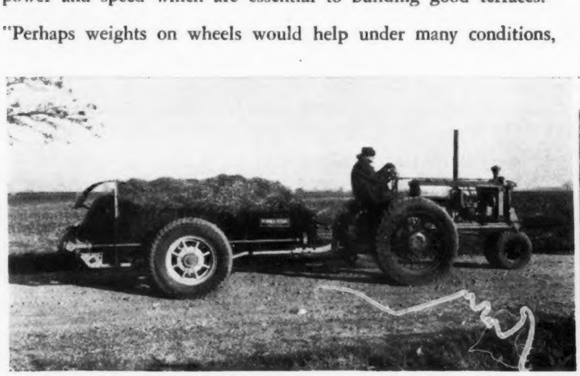
" . . . On a plowed field, harrowing or disking, they do not ride easier than steel wheels as they have a tendency to bounce as they do not break the clods but go over them."

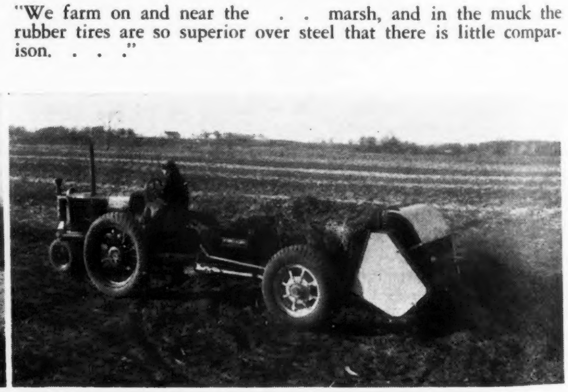
" . . . I also have rubber tires on my plow. My cultivator, mower, and corn picker are also rubber-tired for they are loaded on the tractor. . . ."

"The most important point that has been missed by the questions is the cleanliness. . . We have found three things are necessary to traction: 1st, wheel weights, plenty of them; 2nd, high hitch; 3rd, low inflation, about 10 lb. . . We consider steel wheels obsolete and will not use any tractors on them next year."

" . . . I expect to equip all wheel types with rubber next year for we find more use for tractors so equipped under a greater variety of use than heretofore on steel wheels. In fact, we are using wheel types on rubber to take the place of work heretofore thought only possible to do with crawlers."

"We farm on and near the . . marsh, and in the muck the rubber tires are so superior over steel that there is little comparison. . . ."





THE AGRICULTURAL ENGINEERS OF PURDUE UNIVERSITY AGRICULTURAL EXPERIMENT STATION WILL SHORTLY MAKE A STUDY OF THE EQUIPMENT SHOWN IN THESE PICTURES TO DETERMINE THE COST OF USING IT FOR HAULING MANURE TO DISTANT FIELDS. THE TRACTOR AND POWER-TAKE-OFF-DRIVEN MANURE SPREADER EQUIPPED WITH LOW-PRESSURE PNEUMATIC TIRES MAKE IT POSSIBLE TO HAUL ON THE HIGHWAY AND SPREAD THE MANURE ON THE FIELD WITHOUT ANY CHANGE IN EQUIPMENT. THIS OUTFIT CAN TRAVEL 10 MPH ON THE ROAD, THUS MAKING POSSIBLE THE ECONOMICAL SPREADING OF MANURE ON DISTANT FIELDS. THE SPREADER HAS A CAPACITY OF APPROXIMATELY TWO HORSE-DRAWN SPREADER LOADS

"Have had considerable trouble plowing heavy land that is slippery when wet. . . ."

" . . . We find (in mowing golf course turf) the rubber tires are a great improvement over the metal wheels and lugs. . ."

"I have had trouble with the tire slipping on the rim. . . I inflated the tire to 20 lb and it still slipped."

"We have used these tires monthly on the road. There are some places they do not perform perfect. Also there are more places that metal wheels do not perform perfect."

"The four-ply tires will puncture with dry cornstalk stubs. We are putting reliners in the four-ply tires."

" . . Needs four speed transmission with range of speed up to 15 miles per hour."

"For planting corn they are much better because they do not fill up at times and change the height of the planter tongue. Cutting corn they work much smoother because of not filling up when it is wet. . . ."

" . . . Rubber tires do not cut up the young clover seeding when binding grain or combining, nor the stand in the hay field."

"I bought these tires primarily for haying in alfalfa as I have 100 acres to put up and I want to say that they are sure the thing for mowing and bucking hay."

" . . . In these hay flats the rubber tires are wonderful. They will pull a load in dry, loose sand where a lug tractor will not pull its own weight. . . ."

"Our tractors are driven in from the field every night and are greased, fueled, and such repairs as are needed taken care of before tractor starts out in the morning. This would not be practical with a steel wheel tractor."

" . . . My tractor high gear is 4 miles per hour. It should be twice that for hauling."

" . . . More clearance between belt and front wheel had to be provided by lengthening the front axle after installing pneumatics."

" . . . and another thing, you do not ride in a cloud of dust. They leave all the dirt on the ground where it belongs."

"No horse power on the farm; tractor does all the work."

"Driving over irrigation ditches or plowing crossways in vineyard is about the only drawback I experienced."

"I haven't been able to ride steel wheels for the last three years on account of the jar. I did all my tractor work in 1934. . . ."

"Have had no work horses for over one year."

" . . . The spiked wheels left a large hole which would cause the golf ball to come to rest in, and cause the golfer many lost strokes, etc."

" . . . I would very much like to see a standard hub adapted to farm machines so rubber tires and wheels can be used on more than one machine. . . ."

"The only trouble we have had has been from too low air pressure on hard plowing. Our best traction is when the tires are inflated to about 20 lb. . . ."

" . . . The only slippage encountered is early in the morning on green, grassy land when it is covered with a heavy dew. Wheel weights would be of very little use. The only thing to do is to wait until the dew has dried off. . . ."

" . . . It is one of the best investments I have ever made."

" . . . Our soil is of the sandy type. Don't think I can say too much for rubber tires for our soil. Rubber tires have solved our traction problem."

"It seems to me that rubber tires on tractors should be used in the Nebraska tests, if they are not."

"Rubber tires are the only tires for road work. . . . While they ride easier for some kinds of work on the farm, I find that in using the tractor for field work such as disking, harrowing, and cultivating, I would sooner use the steel wheels if they have good long spades and wheel cleaners. . . . believe a tractor owner should have both types of wheels for the rear. . . the rubber for the front should be of a size so that the tractor would not nose down when the steel wheels are put on the rear. . . ."

" . . . We change to steel wheels for all tillage work. . ."

" . . . We couldn't do all those jobs without tires on the tractor. However, rubber-tired tractors on a side hill aren't worth a damn."

" . . . We have found that with rubber tires we can keep our drive belt tighter than with steel wheels. . . ."

" . . . The bounce of the rubber in crossing ditches, etc., makes it rough riding in the field. . . ."

" . . . In using rubber tires for belt work I notice that they absorb most of the vibration. It is necessary to ground the tractor when used with a rubber belt on account of the static electricity developed. . . The rubber tires on tractor and picker enable us to pick corn where we never could before. . . ."

" . . . There might be some advantage in keeping the dust off the fruit also."

" . . . We have a spark plug air pump and usually put in a little air once a week. . . ."

"Must have better brakes for rubber tires."

" . . . Rubber is the thing for tractor work in citrus grove work. . . ."

"The normal load of the . . tractor on steel tires would be two 14-in bottoms in second speed. With rubber tires we have been able to pull two 18-in bottoms in third speed in sweet clover sod. The . . tractor has four speeds, and we could occasionally pull the load on the fourth speed."

"I am satisfied that this questionnaire is in the interest of the tire companies and I want you to know that I am thoroughly dissatisfied with rubber-equipped tractors so far as farm operations are to be efficient. My reason for purchasing a rubber-equipped tractor was with the idea of eliminating animal power. I was told by the salesman that rubber tires with a 12-lb pressure had more traction than steel wheels with steel lugs. They deliberately tell an untruth when making such statements. You will not be able to find a single salesman that has the guts to come on my farm and make a demonstration, provided, of course, that he knows that I have been using rubber equipment. In harvesting, rubber-equipped tractors are fairly good but only from the standpoint of not cutting up grass-seeded fields. I got stuck in taking the wheat binder from shed to field, pulled both out with a steel-wheeled tractor. In making hay this fall I hooked the . . tractor to two loads of hay and started out of the field on a hard, dry surface with a slight incline. The tires skidded. With the assistance of my . . car hooked to the tractor, we were able to get to the barn. The . . . motor has more power under any and all road conditions than there is traction in the rubber tires, and I stand ready to prove my claims. I have tried to make my points plain and hope that same will be of some benefit to some dirt farmer."

"Last fall we dug a trench silo with two . . tractors; one with 9.00x36 tires, the other with spade lugs. Several times the steel outfit got stuck and we just hooked on with the tires and pulled it out easily. All in all, they are OK."

"Pay many times over on front wheels as bearings last much longer and need less grease. No skid rings to get loose. Tires slip in second under hard pull; therefore, first gear is useless, except where a slow, governed speed is desired. Pretty hard on plows and disk harrows pulling as fast as high gear."

"I have had considerable trouble getting the rear tire off wheel from . . tractor. I take weights off, then jack wheel up, and take wheel off tractor, then take tire off wheel. I suppose an expert could take the tire off without removing the wheel but I found it difficult as the tire was wedged and stuck to the rim of the wheel. . . ."

"My brother and myself have each a . . of the same type but his has steel wheels. We also own a 10-ft . . combine. In pulling this combine, his tractor labored under a heavy load on level ground and he had to shift to low on slight grades. My tractor with rubber tires pulled the combine in fine shape up all the grades in second gear even with the tank full of wheat."

"If I had a farm all in one piece, and did not have to cross highways or roads, I would just as soon have a steel-wheeled tractor."

"We dug three underground silos this year, 200 ft long, 15 ft deep, and 12 ft wide. The trailers were pulled in the pit with rubber-tired tractors, unloaded and used to pack the silage. May I say nothing else could have done the work at such small expense? The packing done by the tractor and the type of packing more than saved the extra cost of the rubber. I would not consider a tractor without rubber."

" . . . I find by using rubber tires I reduce the wear on machinery used with the tractor at least 30 per cent. Dust grinds out bearings of all kinds but the rubber tire picks up very little dust. When I ride the rubber-tired tractor my wife does not have to take the broom to me before I can come in the house. I have no horses on my farm. Consequently I use the tractor for all my work. When using a tractor for planting and the like jobs, you have to make a turn directly about with the tractor and machine, which means that the tractor comes very close to the machinery involved and if a man is not very careful the lugs of an iron wheel will catch in the machinery. A new hired man is sure to smash things up. With the rubber tire, this menace is eliminated because they will not catch the machinery."

"On a moderate load it works fine. If you want the tractor to pull a full load, you can not get along without some slippage. On a dead pull they are no good. This fact is what makes tractors with tires last longer. I have never yet seen my tractor slug down. Of course, this makes it impossible to jerk the gears, too."

"I believe the front tires are unnecessary. They do not facilitate traction in driving power, nor accelerate speed of operation. They are too wide for entering row crops during the growing season even with a pitched front axle."

"Believe that rubber tires will work out of mud better than lug wheels. The side walls seem to give much more traction in fairly firm mud than it is possible to get with steel wheels. Rubber tires will not bury themselves where a lug wheel will. In answer to the question, 'Do you feel justified in having gone to the expense of buying rubber tires?' would say if a satisfactory adjustment is made on my tires, yes; otherwise, no. Rubber on the tread is tearing apart. If this is not corrected, the tires will prove far too expensive for any tractor. I believe the tires will have to last five to six years anyway to pay for themselves. Mine are starting to go bad but probably due to inferior materials used in their manufacture."

"I bought the . . tractor to cultivate and dust my potatoes. With rubber tires there is less damage to the vines. I find I have many jobs like drilling fertilizer, pulling my six-row onion seeder, which it will do handier with one-half the fuel consumption. I have never owned a wheel tractor but with only one tractor I could not do my work with rubber tires when wet and muddy."

"Rubber tires saved us $100 in fuel this year, also a big savings on the tractor, combine and corn-picker. . . . It's a great help in going over small clover when combining. It will not stunt it a bit. You will gain enough in one year to pay for the set of tires and also the man that runs it steady will last more years."

"One man can move the tractor forward or backward by pushing or pulling in order to hook it up to tools by himself. . . . Does not mix dirt into hay and down silage corn in running over it. Does not pick up dust like lugs."

"When conditions are right, I like the rubber tires better than the steel, but in mud or wet spots they are practically helpless. Do not believe I would recommend them for dependable, all-around work."

" . . . I especially like rubber for ease of operating. I have driven this rubber engine 20 hours straight and another time 30 hours out of 36 and still not be tired except for sleep."

"Rubber tires ought to last more than one year. It looks like I will have to buy one new tire before another year is out. . ."

" . . . As for doing more work per day, will say that most of our machines can only be run about so fast to do a good job."

" . . . My tractor was one of the first put out and was too high speed to start with and 36x9.00-in tires made it too fast with the result that it did not have the power that steel wheels had and they made driving so tiresome that I much prefer the steel wheels. The 24x11.25-in tires were too wide to cultivate corn."

"The . . tractor was buried continually in our very sandy, plowed soil with all implements out of the ground, when equipped with the 12-in wheels and lugs. With rubber tires, it handled the four-row cultivator with full implement load in fourth speed. On flat work, where the steel wheels did work, the rubber-tired machine doubled the daily acreage."

"Haven't used tractor much except for digging potatoes and find it damages less potatoes, is faster and much more satisfactory than a wheel-lugged tractor working in a nearby field. . . ."

The Questionnaire Sent to 3,000 Users of Rubber-Tire-Equipped Farm Tractors

A REPORT OF EXPERIENCE WITH PNEUMATIC RUBBER TIRES FOR FARM TRACTOR USE

NOTE: *Please fill out and mail to American Society of Agricultural Engineers, St. Joseph, Michigan, using enclosed envelope which requires no postage.*

Your name ....

Address ....

	Number tractors owned	Make of tractors	Model of tractors	Number on rubber	Date tires bought	Was tractor bought new on tires?
1	....	....	....	....	....	....
	....	....	....	....	....	....
	....	....	....	....	....	....
	....	....	....	....	....	....

2 Number of acres farmed.......... Acres in Corn.......... Wheat.......... Oats.......... Cotton.......... Hay.......... Orchard.......... Potatoes.......... Vegetables..........

3 Check the following jobs which you have done with your rubber-tired tractor. Plowing.......... Disking.......... Harrowing.......... Cultivating.......... Planting.......... Haying.......... Corn Picking.......... Potato Digging.......... Spraying.......... Combining.......... Pulling Trailer.......... Orchard Work.......... Custom Work (Threshing.......... Silo filling.......... Shelling..........)
Other work..........

4 Check the types of soil in which you use your rubber-tired tractor: Clay.......... Sandy Clay.......... Very Sandy.......... Gumbo.......... Muck.......... Stony.......... Other types..........

5 Is your land level or hilly?..........

6 How many hours per year do you use your tractor in field work?..........

7 Do you use tractor for hauling on the road?.......... Hours per year..........

8 Do you do custom work for other farmers?.......... Hours per year..........

9 Do you use your tractor more since putting on rubber tires?..........

10 How much do the tires save in fuel?..........

11 How much more work can you do in a day with rubber tires?..........

12 Have tires reduced breakage and repairs?.......... How much?..........

13 Do you operate tractor in higher gear with rubber tires?..........

14 Do the tires give satisfactory traction?..........

15 Do you have trouble with tires slipping in mud?..........

16 Do you ever use chains?.......... Under what conditions?..........

17 How many weights per wheel do you use?..........

18 Have you had any punctures or flat tires?.......... If so, how caused? ....

19 How often do you inflate tires?..........

20 Do tires ride easier?..........

21 Do rubber tires pack the soil more than steel wheels?..........

22 Are tires satisfactory for belt work?.......... If not, why?..........

23 Do you have any work for which rubber tires are not satisfactory?.......... If so, what is it?..........

24 What farm machines other than tractors do you think would be more satisfactory if equipped with rubber tires?..........

25 If buying a new tractor, would you want it equipped with rubber tires?..........

26 Do you feel justified in having gone to the expense of buying rubber tires?.......... If so, what are your most important reasons?

General Remarks (Add any comment or ideas you think would be helpful in this survey.)..........

TWO VIEWS OF THE EQUIPMENT, INCLUDING WATSON DRAWBAR DYNAMOMETER, USED IN THE PURDUE STUDIES OF THE USE OF LOW-PRESSURE PNEUMATIC TIRES ON A COMBINED HARVESTER-THRESHER

Application of Rubber Tires to Combines[1]

By I. D. Mayer[2]

THIS IS A PROGRESS REPORT of one season's work with low-pressure pneumatic rubber tires upon a combined harvester-thresher. The very noticeable wear and tear and the resultant necessary repairs caused by the vibration of the combine when used on the comparatively rough grain fields has been a maintenance problem which was especially serious during the dry harvest seasons. These tests were run to determine the possibilities of reducing the vibration of the combine by the use of low-pressure pneumatic tires, and also to determine any differences in drawbar pull and fuel requirements which might result from the use of rubber tires on both the combine and the tractor when compared with standard steel-wheel equipment.

The equipment used in these tests consisted of a McCormick-Deering No. 20 combine (8-ft cut) with auxiliary motor and an F-20 Farmall tractor. No alterations other than the wheel equipment were made upon the combine or the tractor. The tires used were of standard sizes and as nearly as possible the same diameter as the steel-wheel equipment replaced. If a combine were being designed for the use of pneumatic tires, probably smaller sizes of tires would prove more economical. The steel-wheel equipment for the combine consisted of the regular wheels, 6x48-in grain wheel, 10x48-in tank wheel and two 4x20-in wheels for the front truck. The rubber equipment consisted of the following low-pressure pneumaitc tires mounted on drop-center rims: grain wheel, 9x36-in; tank wheel, 12.75x 28 in; front, two 5.50x16-in tires. This rubber equipment made the outside diameter of the large wheels practically the same as the steel wheels. The tires on the front trucks were slightly larger in outside diameter than the steel wheels. This resulted in some difficulty in turning with the rubber equipment, because there was insufficient clearance for short turns. The drop-center rims used were, however, the smallest standard rims available.

The steel equipment on the tractor consisted of the standard 12-in rims with spade lugs on the rear wheels and the regular two front wheels with skid rings. The rubber equipment for the tractor consisted of 9x36-in low-pressure pneumatic tires on the rear and two 6x16-in tires for the front wheels. Air pressure in all tires, except that in the tank wheel, was maintained at 12 to 15 lb. The tank wheel tire was inflated to 25 lb pressure.

Tests were run during the wheat harvest when the soil was very dry and hard and also in the soybean harvest when the soil was relatively dry but comparatively loose, as is usually the case in the soybean field. The tests in the wheat harvest were run on sandy loam soil and on clay loam soil. The surface of the soil in the wheat fields was quite rough.

Vibration recordings were made with a solenoid accelerometer fastened rigidly to the top of the main body of the combine under the grain tank. The acceleration in feet per second caused by the jolting of the combine was electrically recorded as the number of accelerations of definite intensities.

Drawbar pull of the combine alone and also the tractor and combine together was measured with the Watson dynamometer on each soil type for each type of wheel equipment.

Fuel consumption tests were run on separate lands of the same size and with as nearly uniform ground and grain condition as possible. Fuel consumption of the tractor only was recorded, for changing wheel equipment would not affect the fuel consumption of the engine upon the combine.

VIBRATION TESTS. Table 1 shows the solenoid accelerometer recordings taken in the wheat harvest on Crosby silty clay loam and Fox sandy loam. The recordings indicate the number of vibrations received which would cause the indicated acceleration in feet per second. The vibration trials were run across the drill rows. The soil was hard and dry and consequently quite rough. The rubber tires ironed out much of this irregularity and reduced the number of accelerations of all intensities. The rubber tires apparently reduced the intensity of the severe jolts and very largely damped the minor jolts so much that the number recorded was greatly reduced.

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[1]Paper presented at a meeting of the Power and Machinery Division of the American Society of Agricultural Engineers at Chicago, December 3 and 4, 1934.

[2]Associate in agricultural engineering, Purdue University Agricultural Experiment Station. Mem. ASAE.

TABLE 1. VIBRATION TESTS ON COMBINE RECORDED BY SOLENOID ACCELEROMETER

Force of vibrations in acceleration, (ft/sec)²	Number of vibrations: Clay Loam, Steel wheels	Clay Loam, Rubber tires	Sandy Loam, Steel wheels	Sandy Loam, Rubber tires
10.7 — 17.2	274	29	227	2
17.2 — 19.3	67	22	62	2
19.3 or greater	60	20	28	2

In reading Table 1 it should be kept in mind that the severe jolts were recorded on each of the lesser recording dials. Thus the 60 vibrations recorded for the clay soil in the 19.3 fps (feet per second) interval were also recorded in the 17.2 to 19.3 fps interval and also in the 10.7 to 17.2 fps interval. Hence, on the clay soil with steel wheels there were 60 vibrations causing accelerations of 19.3 fps or greater, seven additional vibrations 17.2 to 19.3 fps and 207 more vibrations of 10.7 to 17.2 fps. With rubber equipment all but seven of the minor vibrations had been cushioned to such low intensity that they were not recorded and only 20 severe shocks were recorded. In making these tests the combine was run over as nearly the same ground as possible for both steel and rubber without following in the same tracks.

DRAWBAR TESTS. Drawbar tests were run using the Watson drawbar dynamometer for measuring the pull. This was a recording dynamometer of the hydraulic type which recorded the time and distance traveled in addition to the drawbar pull. Tests were run on the combine alone and upon the combine and tractor together. These tests were run with the regular steel-wheel equipment and also with the pneumatic tires upon Fox sandy loam and Crosby silty clay loam soils during the wheat harvest and upon Brookston silty clay loam in the soybean harvest. During the wheat harvest both types of soil were very hard and dry and the surface was quite rough especially when crossing the drill rows. In the soybean harvest the soil was reasonably dry but not dusty. The surface soil was loose and soft and fairly smooth, quite representative of the average soybean field. The results of these tests are shown in Table 2.

TABLE 2. DRAWBAR TESTS

	Drawbar Pull in Pounds: Steel equipment	Rubber equipment
PULLING COMBINE ONLY		
Wheat harvest (sandy loam soil)	326	202
Wheat harvest (clay loam soil)	472	193
Soybean harvest (dark loam soil)	550	335
Soybean harvest (dark loam soil)	618	310
PULLING TRACTOR AND COMBINE		
Wheat harvest (sandy loam soil)	1092	350
Wheat harvest (clay loam soil)	1083	331
Soybean harvest (dark loam soil)	1124	568
Soybean harvest (dark loam soil)	1197	617

As indicated by the data in Table 2 the drawbar pull of the combine was greatly reduced by the use of rubber tires. The rolling resistance of the tractor was also reduced, so that when completely equipped with pneumatic tires the drawbar pull necessary to move both implements was only from one-third to one-half of that required for steel equipment. On hard dry soil in the wheat harvest the drawbar pull of the combine alone was small enough that the combine was pulled for a complete round of the field by a ½-ton truck. This reduction in drawbar requirements not only reduced fuel consumption but in some cases would make possible the use of smaller tractors for pulling combines.

FUEL CONSUMPTION TESTS. Fuel consumption trials were run for the rubber and the steel wheel equipment in the wheat and in the soybean harvests. Lands of equal area and as nearly alike as possible in regard to the condition of the soil and the grain were harvested and fuel consumption recorded by weight as shown in Table 3.

TABLE 3. FUEL CONSUMPTION TRIALS

Equipment: Combine	Tractor	Time of run	Speed, mph	Fuel consumed (gasoline), lb	Per cent (steel equipment equals 100%)
COMBINING WHEAT — Sandy Soil					
Rubber	Rubber	41'42"	3.70	5.0	61.7
Steel	Rubber	41'25"	3.57	6.9	85.2
Steel	Steel	45'40"	3.41	8.1	100.0
Clay Loam Soil					
Rubber	Rubber	1'3"	3.97	7.5	62.0
Steel	Rubber	1'4"	3.88	10.0	82.6
Steel	Steel	1'10"	3.56	12.1	100.0
COMBINING SOYBEANS					
Rubber	Rubber	40'0"	3.32	10.0	64.5
Steel	Steel	50'0"	2.73	15.5	100.0
Rubber	Rubber	50'0"	3.25	12.0	63.2
Steel	Steel	61'0"	2.62	19.0	100.0

NOTE 1. In trials in wheat harvest tractor was run in second gear, throttle open.

NOTE 2. In trials in soybean harvest tractor was run in first gear, throttle open.

Reductions in fuel consumption with pneumatic tires were closely correlated to the reductions in drawbar pull of the combine and in rolling resistance of the tractor. When both tractor and combine were equipped with pneumatic tires fuel consumption of the tractor was approximately one-third less than for all steel wheel equipment under similar field conditions. This saving in cash outlay for operations was the advantage which would be most quickly noticed by the farmer operator.

OTHER FACTORS. The use of low-pressure pneumatic tires on the tractor and combine brought in other factors which were of more or less importance. Rubber equipment made for comfort of the operators, for the machines rode more smoothly and the job was cleaner. (Lugs on the tractor threw up a quantity of dirt and dust which was disagreeable to the operators.) The threshing of the grain was cleaner when rubber equipment was used, no doubt because of the reduced jolting of the combine. The cleaner threshing was much more evident when combining wheat on hard rough soil than when harvesting soybeans on comparatively loose soft soil.

Transportation of the machine when rubber equipped was easier for the entire outfit could be driven down the highway without any additional equipment such as trucks or trailers which were necessary when moving the steel-lugged tractor. The rubber-equipped tractor and combine were safely moved on the highway at ten miles per hour. The rubber-equipped tractor did less damage to young clover and alfalfa in small grains than did the steel-lugged tractor. In soft soil such as was encountered in the soybean harvest, the rubber-tired wheels did not cut into the soil as much as did the steel wheels. This permitted more uniform cutting and more efficient harvesting, where cutting close to the ground surface was necessary.

While no punctures were experienced during this year's harvest season the puncture hazard was always present. Heavy weed stubble had no visible affect upon the tires and did not cause punctures. The low rolling resistance of the combine caused it to gain speed on the tractor when going down grade. Under some conditions this would have been hazardous. Safety appliances should be provided when rubber tires are used. Transportation on the highway with rubber equipment, particularly if *(Continued on page 60)*

Methods of Testing Drivewheels and Tracks[1]

By A. W. Clyde[2]

IT WAS POINTED OUT a year ago that most of the tests on rubber tires and steel wheels for tractors have little quantitative value because the efficiencies of both engine and wheel are usually combined. If, for example, the fuel is measured for plowing an acre with both sets of wheels, the result seldom gives the true comparison. The wheel diameters are usually different, giving a change in effective gear ratio and sometimes the tests are also made with different gears. This together with a change in rolling resistance makes the load factor on the engine entirely accidental. Actually an accidental combination of engine and wheel is being studied instead of the wheel alone.

In order to study a wheel or track, the following should be found for various pulls:

1 Input force or tractive force on the wheel or track sprocket at the no-load rolling radius or rim as selected. This is secured by measuring the input torque delivered to the drivewheels and dividing by the proper radius. On level ground at low speeds this force is used in overcoming the rolling resistance and drawbar pull.

2 Drawbar pull or output force.

3 Slippage or travel efficiency. This may be based on the rim of the wheel, but I prefer to base it on the distance travelled per revolution at no load under the tractor's own power. This gives 100 per cent travel at no load. The wheel radius used for slippage should also be used for getting the input force in (1).

Tests of this nature on steel wheels and tracks have been reported by Collins[3] and McKibben[4]. Figs. 1 to 4 give some results at the Pennsylvania Agricultural Experiment Station on steel wheels, pneumatic tires, and an experimental cushion rubber tire. The tests were made on a level course of Hagerstown silt loam. The soil was dry at the surface but moist underneath. Usually the runs were for 10 revolutions of the drivewheels, data being secured for both wheels. The inlet manifold vacuum method was used for getting driving torque. Considerable effort was made to avoid the errors mentioned later in connection with this method, and the results have been partly checked by the apparatus shown in Figs. 5 and 6. On sod and on loose surface ground the load was supplied by an Iowa constant pull dynamometer, while on plowed ground the loading was by a spring-tooth harrow or disk with a recording dynamometer for measurement.

To illustrate the meaning of the curves, the pneumatic tire in Fig.4 at a drawbar pull of 1000 lb may be selected. This tire had a no-load rolling radius of 2.22 ft and about 1500 lb force at this radius was needed to pull 1000 lb at the drawbar (500 lb being needed to move the tractor). The force efficiency was thus about 66 per cent. At this load the tractor travelled 80 per cent as far per revolution as at no load. The overall efficiency was therefore 80 per cent of 66 per cent, or 53 per cent.

[1]Paper presented at a meeting of the Power and Machinery Division of the American Society of Agricultural Engineers at Chicago, December 3 and 4, 1934. Publication authorized by the Director of the Pennsylvania Agricultural Experiment Station, January 9, 1935, as Technical Paper No. 676.

[2]Agricultural engineer, The Pennsylvania State College. Mem. ASAE.

[3]Collins, E. V. "Efficiency Tests of Tractor Wheels and Tracks." AGRICULTURAL ENGINEERING, vol. 14, p. 35-38, Feb. 1933.

[4]McKibben, E. G. "Some Effects of Diameter on the Performance of Tractor Drivewheels." AGRICULTURAL ENGINEERING, vol. 15, p. 419-23, Dec. 1934.

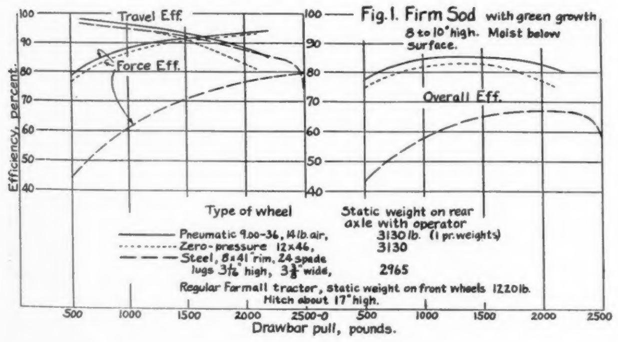


Fig. 1. Firm Sod with green growth 8 to 10" high. Moist below surface.

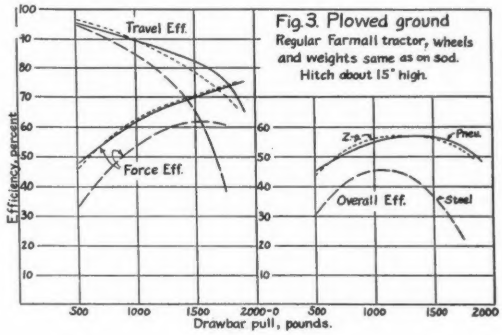


Fig. 3. Plowed ground. Regular Farmall tractor, wheels and weights same as on sod. Hitch about 15" high.

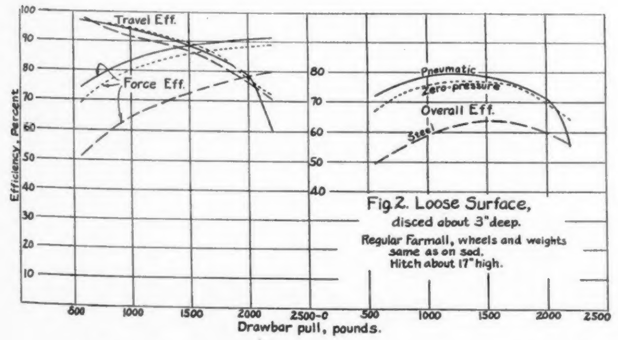


Fig. 2. Loose Surface, disced about 3" deep. Regular Farmall, wheels and weights same as on sod. Hitch about 17" high.

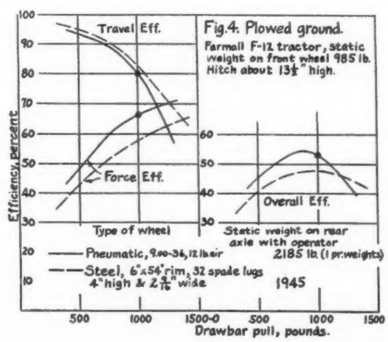


Fig. 4. Plowed ground. Farmall F-12 tractor, static weight on front wheel 985 lb. Hitch about 13½" high.

The zero-pressure tires of Figs. 1 to 3 were weighted so that they had the same static axle load as the pneumatics with one pair of weights. It should be noted that the steel lugs in these three tests were rather short on account of wear and that the rims were 8 in wide as needed for narrow row crops such as potatoes. Rims and lugs of other dimensions might have given better results. Other amounts of weight on rubber tires would also be expected to change their performance. An approximate comparison of the effect of adding 945 lb to pneumatics is given by Figs. 3 and 4, though the tread design was not the same in the two cases. At light pulls the overall efficiencies were about the same. Above a 900-lb pull the efficiency of the lighter loaded wheels fell off sharply because of slippage, while the heavier loaded wheels went to about 1500 lb before their efficiency fell off. At 16 per cent slip, which occurred at maximum overall efficiency, the pulls were 1380 and 910 lb. Additional weight of 945 lb therefore increased the pull 470 lb at this slip, or about 50 per cent of the added weight.

With the exception of sod, the differences between pneumatics and zero pressures are of little significance, because most of the differences are within the limits of accuracy of the measurements.

It would seem that these and other tests on traction devices show the following questions to be of most importance for future improvements:

1 Steel wheels. How can the rolling resistance be reduced without sacrificing too much on slippage?

2 Rubber tires. How can the slippage be reduced without objectionable increase in weight?

3 Tracks. How can the cost of manufacture be reduced?

Obtaining the torque input to the drivewheels or sprockets presents several problems. Three methods were considered, namely, (a) inlet manifold vacuum (or pressure), (b) a cradled engine or transmission, and (c) torque measurement at the drive axle. A fourth method, calibration of the engine by fuel consumption, was also considered but was discarded because it has many of the drawbacks of the vacuum method and because of the length of time and distance needed for a reading. The discussion will, therefore, be limited to the three methods mentioned.

INLET MANIFOLD VACUUM. The author has worked with this method as has the Nebraska agricultural experiment station[5] and agrees with their statement of its "treacherous inconsistency." Such factors as barometric pressure, air temperature, valve condition, speed, water temperature, oil viscosity, fuel mixture, and possibly the distribution of the fuel to the different cylinders, so affect the engine calibration as to make the results doubtful. The common correction for barometer and air temperature has been used to take care of these two variables. There is, however, a difference of opinion as to whether this correction is good for part throttle conditions, when the inlet manifold pressure is considerably below atmospheric. If a simple way of providing for barometric changes is wanted, it will probably be better to calibrate the engine by absolute pressure in the manifold, but in our experience that is not entirely reliable. Our conclusion so far is that the best way to get reasonable accuracy is to calibrate the engine each day while conditions are about the same as during the wheel tests. If the engine is calibrated by belting it to a brake, there is also uncertainty about the belt and transmission losses. Such elements of doubt could be removed by putting a brake on each drive axle when calibrating, but that would involve expense and time. In view of the difficulties we are convinced that inlet manifold vacuum is a very unreliable and time-consuming method of getting engine torque to say nothing of wheel torque.

CRADLED ENGINE OR TRANSMISSION. The drawbacks to this method are the expense, the fact that it would be difficult to apply to many tractors because of their construction, and the need for calibration to determine the mechanical losses between the point of measurement and the wheels.

TORQUE AT THE DRIVE AXLE. Two variations of this method have been used at the Iowa station. The wheel tractor was equipped for measuring the tension of the final drive chain and the track machine for measuring the reaction supporting the front end of the frame. In the former, a static calibration does not provide for the loss due to chain friction and neither provides for the axle bearing loss. With anti-friction bearings, however, this is a very small item. Another variation of this method would be to arrange a dynamometer between the wheel and an arm connected with the axle. This might involve considerable work in adapting different wheels for test.

Figs. 5 and 6 show a low-cost wheel dynamometer of the front-end reaction style, the principle of which was worked out at the California station[6] (Continued on page 60)

[5]Smith, C. W. and Hurlbut, L. W. "A Comparative Study of Pneumatic Tires and Steel Wheels on Farm Tractors." Nebr. Agr. Exp. Sta. Bul. 291, p. 29-35, 1934.

[6]McKibben, E. G. "Torque Dynamometer for Tractor Drivewheels." AGRICULTURAL ENGINEERING, vol. 9, p. 311-12, Oct. 1928.

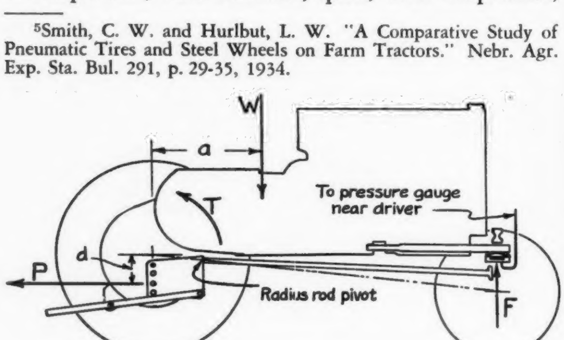


FIG. 5 THIS ILLUSTRATES THE PRINCIPLE OF THE WHEEL DYNAMOMETER REFERRED TO IN MR. CLYDE'S PAPER

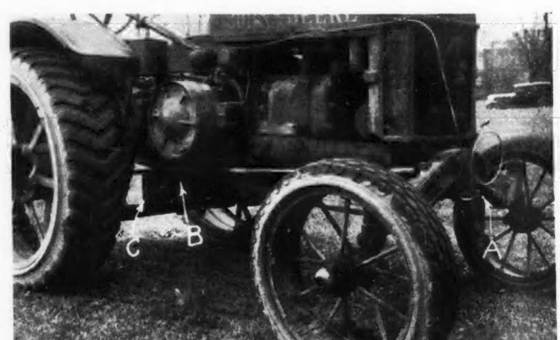


FIG. 6 TRACTOR EQUIPPED TO MEASURE REAR AXLE TORQUE. "A" IS THE HYDRAULIC DIAPHRAGM UNIT CARRYING THE FRONT END OF THE FRAME, "B" THE PIVOT POINT OF THE RADIUS RODS, AND "C" SHOWS SEVERAL POINTS FOR MAKING THE HITCH

Pneumatic Tractor Tires on Listed Crop Ridges[1]

By Frank J. Zink[2]

THE USE of pneumatic tractor tires on listed crop ridges is thought by a number of individuals to be a problem of some magnitude. Although numerous complaints have been made of them for various listed crop operations, similar complaints also have been made of steel-wheel-equipped tractors. However, it is quite apparent that these complaints are more vigorous against rubber equipment. Observations also bear out the fact that the rubber tires on tractors do not give the satisfaction obtained from steel wheels.

The problem lies in lack of steering control and the inability of operator to place and keep in place, upon the top of the ridge, both the front and rear tractor wheels. The problem pertains mainly to those crops planted in the furrow, and hence is confined to the corn and grain sorghum areas of the Central West and Southwest.

To determine how to deal best with the problem, a cooperative study was made of it by representatives of the Firestone Tire and Rubber Company[3] and the Department of Agricultural Engineering of the Kansas State College.

Work was continued by these agencies over a period during the spring season of 1934. The work was done at a time when such field work normally would be under way. Soils were chosen which would be representative and included medium upland and both light and heavy bottom lands. Some twenty acres of land were used throughout the study.

Some of the variable factors are obvious. These factors individually and collectively influence successful operation of tractor equipment in listed crop work by some varying degree. As a means of understanding the problem and clarifying these factors, some general considerations are helpful. These are partially stated in the following paragraphs.

The spacing of rows in listing practice varies similarly to the row spacing of surface planted corn. Most listing equipment permits a variation of which spacings of 38 to 42 in are included. While surface-planted corn appears to be almost universally spaced in 42-in rows, there seems to be a tendency for listed crops to be planted more frequently in rows spaced 38 to 40 in. It is observed that the narrower spacing of listed crop rows results in a sharper and peaked ridge, while wider spacing adds width and flatness to the ridge.

The tread width of row-crop tractors has been planned for clearance of the growing crop and apparently the designers of these machines have not intended to have a tread width exactly twice the row spacing. Some of the tread widths (widest possible) on a number of the more popular row-crop tractors are 74, 75, two at 76, 78, two at 80, 83, 84 and 85.5 in. Further, it is to be observed that the most popular tractors for listed crops when using steel wheel equipment are those having tread widths about twice the more standard row spacing of 42 in.

Soils in the listed crop sections are lighter and less stable under tractor wheels. Frequently sandy areas are encountered. Moisture conditions vary extremely, often very dry, resulting in the ridge being loose, lumpy, or sometimes quite uneven in size. These variable soil and moisture conditions may be encountered during listing or listed crop cultivating periods.

Side grades are frequent and due to a growing tendency to list with the contour, as an erosion control measure, successful negotiation of side grades is important.

Listing equipment is less standardized than surface-planting equipment. Single and multiple rows up to several can be obtained. In tractor equipment 2 and 3-row listers predominate. Many horse listers are adapted to tractor operation. Sulky types predominate which result in considerable inaccuracy of row spacing due largely to lack of directional control by guide wheels operating in the last completed furrow. Many wheatland listers, used mainly for preparing wheat ground, are equipped with planting attachments. A number of these wheatland listers are not adjustable for row spacing and are somewhat narrower than the customary spacing of 42 in, often being spaced 36 and 38 in.

The listing practices differ markedly. Some follow the practice of blank listing with the ridges later being broken out and row being planted in what was the base of the original ridge. Very frequently when following corn with corn or with grain sorghum, the ground is not worked following the last cultivation and the old rows are used as markers for the new rows. In this way a row of corn roots line the top of each ridge which accentuates the problem of keeping atop of the ridge to a considerable extent. Also, unless the operator is rather careful to obtain uniform spacing, much variation will result. These variations consist of narrow and wide spacing of rows due to lack of directional control or side slip of implement and tractor. Such results do not permit subsequent operations to be done with reasonable ease.

Although cultivation practices differ, the usual procedure is to use a listed crop cultivator for the first two operations, and then the ordinary row-crop cultivator for the final operation. In this plan the first cultivation consists of throwing-out, which increases the sharpness of the ridge. The second cultivation consists of throwing-in, which process moves considerable soil and leaves a rather narrow, sharp ridge. This narrow ridge is unavoidably too narrow to support a tractor wheel, yet it lies in the path of the wheel and is a constant source of trouble in steering a tractor. Two throwing-out cultivations are sometimes given before the subsequent throwing-in and cultivation, which results in a still more difficult situation.

With these conditions existing, there is apparent no obvious solution to the problem. The most suitable method of procedure in the study was clearly a general study by case method. Due to inability to set up enough trials and lack of suitable means of measuring results other than observation, few precise measurements or experimental data could be taken. The procedure consisted therefore in testing a series of adjustments, attachment devices, and methods of operation, some of which seemed plausible means of producing more satisfactory operation.

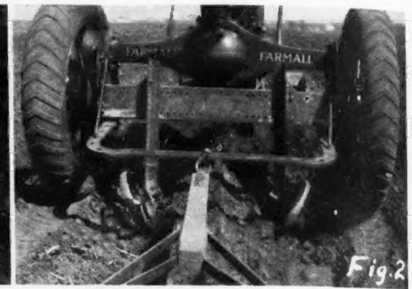
The work was done in the vicinity of Manhattan, Kansas, using upland and bottom-land soils of various types.

[1]Paper presented at a meeting of the Power and Machinery Division of the American Society of Agricultural Engineers at Chicago, December 3 and 4, 1934. Contribution No. 68 of the Department of Agricultural Engineering, Kansas State College.

[2]Associate professor of agricultural engineering, Kansas State College. Mem. ASAE.

[3]The author desires to give credit in particular to Mr. L. L. Baldwin of the field engineering staff of the Firestone Tire and Rubber Company. Mr. Baldwin was in charge of the tests and performed the major part of the work.

FIG. 1 THIS SHOWS TYPICAL TRACKS OF A RUBBER-TIRED TRACTOR OVER LISTED CROP RIDGES. FIG. 2 LISTER RIDGE GUIDE WHEEL ATTACHMENT. FIG. 3 THIS SHOWS THE GUIDE COULTER WHEELS. FIG. 4 THE EXPERIMENTAL REAR-WHEEL GUIDE FLANGE



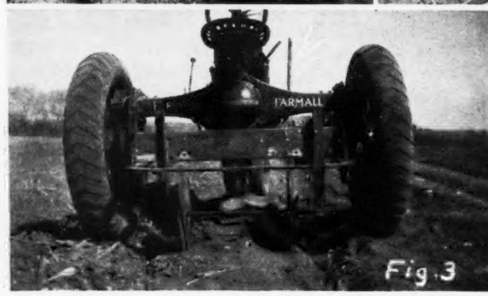


Fig. 1 shows typical tracks of a rubber-tired tractor over listed crop ridges.

The equipment consisted of tire and wheel equipment, tire chains, Farmall 20 tractor, two-bottom pull-type lister, two-row listed corn cultivator, and other minor tools.

In most cases the tests were conducted with the equipment in operation similar to operation in normal farm practice. The work with the cultivator, however, was done within a few days after the ridges were thrown up. Intervening rains would probably have settled these ridges under more normal operation. It is considered, however, that the conditions for cultivating were not abnormally different from those frequently existing.

The following individual devices were tested and investigations conducted:

1. Study of row spacing and tractor-wheel tread width
2. Inflation of tires, different sizes of tires, and tire treads
3. Steering control and steering brakes of tractors
4. Flattening ridge tops by rolling and leveling
5. Guide-wheel attachments and guide coulter wheels
6. Wide-base, drop-center rims
7. Tire chains
8. Guide flange on wheel.

These various investigations were conducted individually and the results observed. In some cases several of the propositions were considered together. Numerous repetitions were made of tests over the different soils. Taking each in the above order stated, the following are somewhat brief statements of the results obtained along with some discussion of those results.

Row Spacing and Tractor Wheel Tread Width. With wheel spacers and by means of reversing the rear wheels, a series of tread-width variations were obtained. These tread widths ranged from narrower to wider by several inches than twice the row spacing. When the tread width was either too wide or too narrow, slight variations in row spacing frequently caused the rear wheels to slip off the ridges. Once the rear wheels of the tractor were off, they would slip along the side of the ridge, although the front wheels remained in position on top of the ridge. To place the rear wheels back on required steering the front wheels on the opposite side for a distance sufficient to bring the back onto the ridge. This is not a satisfactory condition for in this process some length of row of the growing crop would be lost.

It was observed that tread width exactly twice the row spacing minimized this trouble. Therefore it is concluded that the row spacing should be as wide as 42 in whenever possible and that it is desirable to have the tires run exactly on top of the ridges. This seems to be much more important for rubber tires than for steel wheels. It was pointed out in an above paragraph that eight of the ten tractors noted have tread widths less than twice the more desirable row width.

Inflation of Tires, Tire Sizes, and Tire Treads. The various sizes of more standard tractor tires were tested. These sizes included 9x36 and 11.25x24 rear tires and 6x16 front tires. Both front and rear tires were tested for their ridge-top climbing and staying qualities at various inflation pressures. It was obvious that the lower inflation pressures permitted the tire to flex and "jelly" around when climbing the side of the ridge, a condition resulting in poorer operation. Sufficient inflation pressure to give the tire firmness was necessary. Also in this respect the 9x36 tires are more firm than the 11.25x24 at the same air pressure, hence they were chosen as better suiting the conditions. The action of the tire in going off and climbing on the ridge is much the same as that experienced in driving a motor car in a rutted dirt highway.

Two types of treads on the front tires were tested, the chevron type and the ribbed type. The ribbed tread gave better results than the chevron in steering control. The ribs of the ribbed-tread tire were only about $\frac{1}{4}$ to $\frac{3}{8}$ in in height and the grooves rather narrow. These tires were similar to those recently placed on the market by the B. F. Goodrich Rubber Company, although the grooves were narrower. It should be pointed out, however, that neither the ribbed-tread tire nor the chevron-tread tire produced the desired results in front-wheel steering, both necessitating the use of steering brakes. It would appear that a deeper rib tread on the front tire would produce still more desirable results.

It was observed that inflation pressures of the front tires was not an important factor of front-wheel steering with either type of treads.

With the conclusion of these tests and the selection of what appeared to be the best application of tires, subsequent tests were carried out with 9x36 rear and 6x16 ribbed-tread front tires, all at normal inflation pressures.

Steering Control and Steering Brakes of Tractors. Adequate steering control is essential in handling listed crop work. It is obvious that steel wheels and skid bands result in better control than rubber tires. In a num-

ber of cases of use of rubber tires they have been applied only to the rear wheels for this reason. In part, this method of application results in defeating the advantages of the application of rubber tires. In this method of application it is observed that steel wheels can be guided with steering wheel only both on and off the ridge at the will of the operator. Rubber front wheel equipment cannot be operated in this manner without the use of steering brakes. Those makes of row-crop tractors using individual and hand-operated brakes, including both right and left turn, are better adapted for the use of rubber tires on listed crop ridges. As stated above, a Farmall tractor was used in the testing work. In order to use this tractor satisfactorily, it was necessary to improvise a brake lever so that right-hand steering by means of a wheel brake could be had along with the existing left-hand steering.

The conclusion of this phase of the study was that the tractor steering brake is essential in placing the front wheels on top of the ridge, and it is only through their use that rubber tires can be used. With surface planted corn, steering brakes usually need only be used on turning at the ends; however, for listed crops they are needed at times throughout the row length.

FLATTENING RIDGE TOPS BY ROLLING AND LEVELING. In order to flatten the tops of the ridges and give the tire a better chance, two devices were used. The first was an improvised roller made of 10-in well casing and about 7 ft wide, wide enough to cover two rows. This roller weighed slightly under 200 lb and was trailed behind the lister. The second device for the purpose was a plank drag with edges of the planks lapped. This also was wide enough for two rows and was trailed behind the lister.

Both of these devices provided a flatter topped ridge which aided the tires in staying on top. Although the use of either implement resulted in a steeper side slope of the ridge, this did not reflect in poorer ability to climb the ridge nor in the rear wheels falling off.

These devices are recognized as extra implements usable under certain circumstances and desirable only in case less effective and less simple methods could be found. Their use would partially offset the advantages of the rubber tires.

GUIDE WHEEL ATTACHMENT AND GUIDE COULTER WHEELS. Both of these devices were used as attachments. They are shown by Figs. 2 and 3. The purpose of these attachments was to maintain the wheels in position. Any

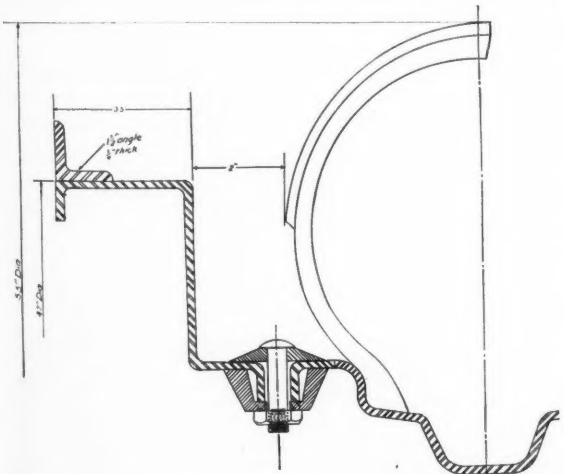


FIG. 5 DETAIL DRAWING OF THE EXPERIMENTAL REAR-WHEEL GUIDE FLANGE

attachments so used must have a means of vertical and flexible adjustment to prove effective. It was found that, when the tractor wheels slipped off the ridge, the guide wheel attachment took the weight of the tractor, preventing adequate traction of the tractor drivewheels. Coulter wheels were resorted to for preventing loss of traction, but they also were observed to carry some weight. They aided in preserving a straight line motion. They appeared to be as effective in keeping the wheels off the ridges as on the ridges. Neither of these methods was very satisfactory.

WIDE-BASE, DROP-CENTER RIMS. Wide rims for both diameters of rear tires were used—an 11-in rim for the 11.25x24 and an 8-in rim for the 9x36-in tires. This provided a much broader tread and made the tire considerably more stable. The sides of these tires were nearly vertical and the cross section a "D" shape rather than the typical circular cross section of the standard rim widths. The 9x36 tire with these rims had a cross section of 10.5 in.

TIRE CHAINS. Two types of tire chains were tested on the rear wheels. The first type tested was the truck type having cross chains. These proved of little use in climbing the ridges and of no value in keeping the wheel on the ridge. The second type of chain was one designed with approximately a 3-in lug. These proved very effective, enabling the rear wheel to climb the ridge easily and travel more nearly in accordance with directional control of the front-wheel steering. They were effective in climbing out of the furrow without steering the front wheels off on the opposite side of the central ridge.

It is concluded that the rear wheels with lug chains are practically as effective as the commonly equipped steel wheel. They are recognized as being superior to anything tested, although again their use in part offsets the advantages of the use of rubber tires.

GUIDE FLANGE ON WHEEL. After some speculation, a design of a wheel flange was considered as feasible. This consisted of a narrow steel rim about 3.5 in wide, with a radius 4 in less than the tire radius and mounted 2 in from the side wall of the tire. This extension rim was equipped with short spokes welded to the tire rim. Regular extension rim bolts or clamps would normally be used for ease of removal. In testing these rims it was found that some side slip occurred so an angle-iron skid band was attached.

This guide flange serves only for climbing out of the furrow. When attempting to climb from the trough, the steel rim comes in contact with the shoulder of the ridge and the tire does not slip back into the ditch. This steel rim comes in contact with the soil only when climbing the ridge. One rim on the outside of each rear wheel was used.

It is concluded that these rims were virtually as effective as the lug type chain, and, further, possessing none of the disadvantages of the lug type chain, except the first cost which should be reasonably low. It is also considered that such wheel flanges might also be effective on the front wheels, thereby gaining the same advantages possessed by steel wheels and skid bands. Such equipment is thought to be a fairly satisfactory solution to the problem over all kinds of soil and side hill conditions. They would neither involve any use of power nor offset any of the advantages gained by the use of rubber tires. Fig. 4 shows the experimental rear wheel flange. Fig. 5 shows a detail drawing of the proposed flange.

In general conclusion, this material is looked upon as a fair start on the study of the problem. Due to the inability to set up enough trials or have sufficiently variable conditions, those observations which are made are offered as being based upon best possible judgment. It is recognized

that several of the things studied are merely means of meeting the situation rather than permanently correcting the trouble.

However, it appears that changing the listed crop practices other than wide-row spacing and using care in listing, much of the condition is beyond the control of the operator, and it will be necessary to adapt the rubber-tire equipment to the prevailing practice.

Further in this connection, most of the devices and adjustments tested were applied to rear-wheel control. Nothing was satisfactorily worked out for the front wheels except steering brakes and ribbed tread tires, both of which are insufficient for control. Variable spacing of front wheels is suggested as a means of procuring better front wheel control.

Most of the remedies studied would be classed as makeshifts, useful and helpful perhaps, but not wholly desirable. Therefore, there remains further work to be done.

The following sum up the various measures and recommendations in the probable order of greatest value:

1 Rows spaced 42 in with the spacing as consistent as possible
2 Tractor tread width should be twice the row spacing
3 Under difficult conditions use lug type chains
4 Wheel flanges, both front and rear, appear as the best ultimate solution of the problem of steering control.
5 Rolling and dragging ridge tops was helpful
6 Normal inflation pressures and tire sizes.

Methods of Testing Drivewheels and Tracks

(Continued from page 56)

six years ago. It is a good piece of apparatus for depression times because less than \$20.00 worth of material is needed for it. Wheels from other tractors can be fitted to it by various schemes. The new feature of the apparatus is an hydraulic diaphragm unit for carrying the front end of the frame on the axle. If T is the axle torque, W the weight of the frame and its attachments at a distance a from the rear axle, F_1 the static front axle reaction, and F the reaction when pulling load P, then taking moments about the rear axle,

$$T = Wa - Fb + Pd$$

but when standing still $Wa = F_1 b$

$$\therefore T = (F_1 - F)\, b + Pd$$

To insure accuracy the following points should be observed:

1 The front axle radius rods should be pivoted in the line between the axle centers so that horizontal components of forces on the front axle will have no moment about the rear axle.

2 The hitch should be made in the vertical plane of the drive axle so that distance d can be measured closely and will not change appreciably.

3 The no load force F_1 should be obtained with the tractor in the same position and with the driver in the same position as when F is obtained. Tests can be made on constant grades but a grade correction is then needed.

4 A valve is needed in the pressure line, preferably near the driver, so that fluctuations of the pressure gage can be dampened. A fairly smooth course will reduce fluctuations due to inertia of the front end of the frame.

For this particular tractor the diaphragm unit has an effective area of about 12½ sq in. The no load force F_1 is nearly 1000 lb, giving the gage reading of about 80 lb. The unit with gage was calibrated in a testing machine before it was installed and the no-load reading gives a partial check on the gage thereafter. The diaphragm is an oil-resistant rubber with fabric reinforcement made for such use. Ordinary motor oil serves well in the system.

We have used this outfit enough to have much more confidence in it than in the vacuum method. It tests both drivers at the same time which is not true of some other methods unless the apparatus is made in duplicate. The main improvement which is planned is to put the apparatus on a lighter tractor so that tests can be made with less weight on the wheels. A very light tractor with enough engine torque to pull about a 3000-lb load will be better since it will be easy to add weight as desired. Tests can then be made with axle loads similar to those on both one and two-plow tractors.

Rubber Tires on Combines

(Continued from page 54)

higher than field speeds are to be used, would require the addition of suitable brakes on both tractor and combine to provide safety.

Judging from this one season's tests it appears that the use of low-pressure pneumatic tires on combines offers the advantages of reduced vibration, lower drawbar pull which might in some cases permit the use of smaller tractors, lower fuel consumption, greater comfort for the operators, and much easier transportation on the highways. It appears that the greatest disadvantage of rubber-wheel equipment for combines are the increased cost of the equipment and the hazards of punctures.

The Economics of Long-Lived Farm Structures[1]

By William Boss[2]

AT THE present time when much effort and publicity is being given to surveys of farm building conditions, and encouragement in the matter of financial loans at low rates of interest and long-time repayments is being given to home owners, it would seem wise that we members of the Farm Structures Division of the American Society of Agricultural Engineers should take stock of the farm building situation and attempt to establish a reasonably sound philosophy as to the types of buildings we are to recommend in order that the quality of our work may be such as to justify our being termed "agricultural engineers."

For several years the members of the Division have frequently endeavored to call the attention of agricultural leaders to the importance of repairing, painting, and rebuilding farm buildings as a means of furnishing employment and of maintaining American standards of farm life. It cannot be said therefore that we have been negligent, but I am sometimes inclined to think we have not always been quite as aggressive as we should be in stressing the importance of building good farm structures. During the past year millions of dollars have been paid to farmers of the United States for curtailing their production of food products and thus avoiding the accumulation of an enormous surplus. This would indicate that farmers have been spending too much effort on production and not enough on consumption or upon other kinds of farm work such as the repair or construction of their necessary buildings, and the general upkeep of their farms. I understand the AAA is but a temporary emergency agency, although it will no doubt be continued in a modified form the coming year at least. Surely now is the time to make every effort to start a farm-building program of a substantial magnitude. If action is not soon taken, faith in farming will be lost, effort will cease, and a still more serious depression will follow. There is no other possible movement that would be more helpful to all classes of people, give more universal employment, and return more enjoyment per dollar or per hour of work than a movement that would put a good home of modern buildings on every farm in the United States. One remarkable fact is that a building program keeps the dollars in circulation and they are still here after the buildings are completed.

The construction of buildings has always had an important place in the advancement of civilizations and the discontinuing of building or maintenance of buildings has undoubtedly been one of the chief factors in the declines of civilizations. This is forcibly illustrated in Fig. 1 which covers a period of 7330 years in the past and anticipates a future of 670 years, a total period of 8,000 years. Some persons may object to such a long range of vision, but agricultural engineers have a long-range occupation, and they should not hesitate to make long-range observations in both directions, discuss fundamental factors, and profit by their significance.

This chart (Fig. 1) is based on data partly supplied by the eminent Egyptologist, William Flinders Petrie. It shows the rise and fall of five earlier periods of civilization and the rise of the sixth which would reach its normal height in about 1930, and if history repeats itself, or if the law of periodicity is not overcome, the present depression, just starting, will continue for about 600 years, or until about 2600 when the people then on earth will again start to build another civilization which will excel ours of the present period. The last high period before the present time was about 200 years B. C. followed by the fall of Rome and the Dark Ages. The six factors used by Mr. Petrie in making his analysis were Sculpture, Painting, Mechanics, Literature, Science, and Wealth. In a well-balanced civilization about equal attention or effort is given to each of these factors, and a well-balanced educational system should see that all are properly supported.

I am inclined to think we are giving too much thought to Wealth at the present time, and we are thinking of wealth as in the form of money. Money apparently is becoming the god of many of our people.

I believe we as engineers should desire wealth for our people, but we should realize that wealth is more than money. We should beware of false prophets, or economics which treat only of money. A reasonable amount of money is desirable. Its use, however, is similar to the use of lubricating oil, in that it reduces the friction of barter and facilitates the exchange of goods or property, but it does not take the place of goods or property unless it is made into jewelry or other ware which is desirable.

Wealth includes property, and property comes from the ability of people to do useful work, to produce raw materials such as digging gold, copper, iron, salt, etc., to produce grain and livestock, as well as making tools, building machines, homes, churches, schools, etc.

The United States in the past 300 years has become a very wealthy nation; partly due of course to its natural resources, but largely due to the customs, traditions, and standards which our ancestors brought from other countries and have given to us as the basis for a wonderful type of civilization. We have a rich heritage. May we not be found wanting in our attempts to carry on. We should realize that when men of wealth die, their property and their money both remain here and are inherited by succeeding genera-

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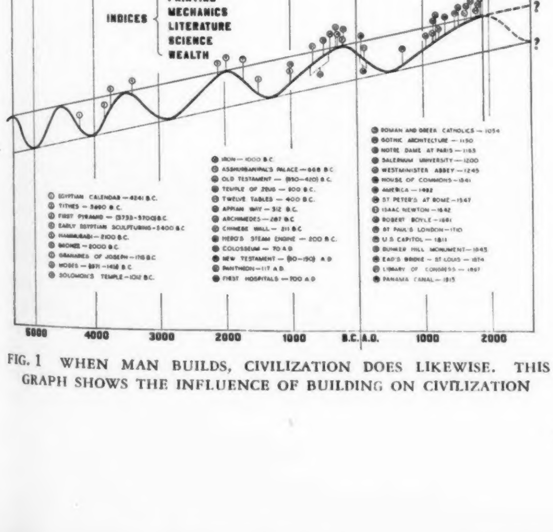


FIG. 1 WHEN MAN BUILDS, CIVILIZATION DOES LIKEWISE. THIS GRAPH SHOWS THE INFLUENCE OF BUILDING ON CIVILIZATION



FIG. 2 (LEFT) A LOG HOUSE WILL LAST ABOUT TWENTY-FIVE YEARS. FIG. 3 (MIDDLE) A FRAME HOUSE WILL LAST ABOUT FIFTY YEARS. FIG. 4 (RIGHT) A MODERN HOUSE WILL LAST ABOUT ONE HUNDRED YEARS

tions. More gold and silver are mined each year, and they remain here either in the form of money, bullion, or precious ware. This accounts partly for the large amount of money in the banks of the United States at the present time. When buildings, factories, machinery, etc., are being constructed, money is in circulation, but it is not consumed. When the building processes are completed, we have both the things built and the money. The money has changed owners and circulates from the workers back to other owners or their bankers to hold for new loans or other investments.

The big problem in the United States at present is to get the money into circulation again in proper channels to the proper persons. One important remedy is to start individuals building good homes and tearing down or rebuilding poor ones, and to pay good wages to persons who work. They will keep the money in circulation by buying an abundance of good food and clothing at good prices and eventually building good homes for themselves and paying their share of our ever necessary taxes. This will keep them out of the farming business and our farmers will again be prosperous.

In the preparation of Fig. 1, I have made a careful study of all important events in world history and have charted here particularly the building of various structures. This chart proves conclusively the theory that when people are busy erecting buildings, times are prosperous, and when they cease to build, they cease to prosper. Evidently man should desire more than food and clothing. Good homes hold the key position in our high type civilization of the present time.

It is interesting to note that the custom of giving tithes or one tenth of one's income to the Lord was established about the beginning of the second rise of civilization within the period outlined by Mr. Petrie, or 3800 B. C. This no doubt influenced a program for constructing temples and buildings for religious worship. At the present time our tithe is often less than one-tenth of our income or increase, and it is not always a free will offering, but it is probably becoming a forced offering in the form of taxes of various kinds. No doubt some serious thought could well be given to this situation. The building of the first Egyptian pyramid, 3735 to 3700 B. C., was also probably one of the factors leading to the advanced period of their civilization. No doubt this was beneficial to the farmers of that time as it gave employment to persons doing work other than farming. In other words, it removed some of the competition in the farming business of those days.

Apparently from 1012 B.C. to 117 A.D. was about 1100 years of prosperity. This period saw the wealth and the fall of Rome. Then followed about 600 years of depression during which time few if any notable structures were erected.

The past 1000 years has seen a most wonderful development of the world civilization. It has seen the erection of many notable buildings, the practical development of the steam engine, the internal-combustion engine, and the electrical generation and transmission of power, thereby utilizing more of Nature's forces and materials.

The use of machines and power greatly increases man's productive capacity. Machines are made to save labor; this tends to lower the wage scale of those who work. We must learn how to keep our balance, how to adjust ourselves to new and better conditions; this calls for real education. We are now living in a Power Age which should develop into an Engineering Age.

Some of the world's most notable structures and the dates of their completion are the following:

3700 B.C.	First Pyramid of Egypt
1715 B.C.	Granaries of Joseph
1012 B.C.	Solomon's Temple
668 B.C.	Asshurbanapal's Palace
500 B.C.	Temple of Zeus at Olympia
312 B.C.	Appian Way, Paved Road
211 B.C.	Great Wall of China
200 B.C.	Hero's Steam Engine
70 A.D.	Colosseum, Amphitheater
117 A.D.	Pantheon, Reconstructed under Hadrian
700 A.D.	First Hospitals, Mohammedan
1054 A.D.	Greek and Roman Catholic Churches
1150 A.D.	Gothic Architecture Introduced
1163 A.D.	Notre Dame at Paris was begun
1200 A.D.	Salernum of Italy, Mother of Universities
1245 A.D.	Westminster Abbey begun
1341 A.D.	House of Commons, England
1492 A.D.	Discovery of America
1547 A.D.	St. Peter's Cathedral at Rome
1769 A.D.	Watt's Invention of the Steam Engine
1843 A.D.	Bunker Hill Monument, U.S.A.
1863 A.D.	U. S. Capitol at Washington
1874 A.D.	Ead's Bridge, St. Louis
1897 A.D.	Library of Congress
1915 A.D.	Panama Canal

During the periods of decline between the high periods of civilization few, if any, buildings of record were built. No doubt many structures have fallen and decayed; some of them, however, have been rebuilt or restored during the rise of the civilizations which followed, notably the Great Wall of China first built about 211 B. C. and rebuilt about 1400 A. D. It is, of course, gratifying to know that some of these old structures are still standing and to feel that some of our present structures in the United States will stand through the coming centuries as reminders of our intelligence and skill in utilizing nature's forces and materials for the benefit of man. At the present time, when ample materials of a desirable character such as portland cement, copper and brass sheets, pipe and fittings, heavily galvanized iron, etc., are available, it is poor economy to build short-lived buildings, or to put too much expense in repairing or remodeling old ones. It is much better to

tear down the old and rebuild anew with the thought in mind that the buildings will last for 100 years or more and serve three or four succeeding generations.

The length of time the average farmer is the manager of a farm is seldom more than thirty years. He then gives way to a younger man. The farm and buildings, however, remain, and when the engineer is counseling a farmer or owner regarding his building problems, he should keep this fact clearly in mind and point it out to him. The farmer as a rule is not thinking so far ahead. His habit naturally is to think only one year ahead.

Most of the farming sections of the United States have gone through the pioneer days, and we have reached a period of time when farm buildings should be standardized so far as general construction is concerned and planned with proper regard to economic returns.

In Minnesota we still have some excellent examples of the developments that naturally take place in establishing a permanent farming business. Most of our farm land was in its natural wild condition seventy-five years ago, and like all new states money was scarce and building materials were limited. The first buildings were usually made from sod or from logs as shown in Fig. 2. They were built by the farmer himself or by local labor when not occupied with other farm work. Many of these had dirt floors and no conveniences. The life of the ordinary log buildings was about twenty-five years.

As time progressed and farmers prospered, saw mills were established and in about twenty-five years these buildings were replaced with frame houses such as shown in Fig. 3. These houses as a rule had a cellar for vegetables, usually under the living room, but no full basement, no furnace heat, no toilet facilities or electric lights. The life of such a house is about fifty years. Its life could be prolonged, but in most cases this is not desirable. They should be torn down and replaced by modern houses such as is shown in Fig. 4. This is a Minnesota farm house having full basement with laundry, hot water heat, soft water cistern under the large rear porch, electric lights, fireplace, hardwood floors and finish, a very fine home for the happy family of five children. How many years will it last? I will predict one hundred years at least, if it is kept reshingled and properly painted. During its lifetime it will provide a good home for at least three or four successive families, and it will be a much more desirable home than either the log house or the old-fashioned framehouse.

History shows that our barns have had about the same development as houses, except that some of the first ones were made from poles covered with straw or slough grass as well as from logs. These lasted not to exceed twenty-five years and were replaced with lightly constructed frame barns lasting about fifty years. These eventually should be replaced with barns of more modern construction such as shown in Fig. 5, which should give 100 or more years of service and add a great deal to the pleasure and satisfaction of its owners. Fig. 6 shows a splendid barn built forty years ago. It still has its original shingles. Its cost in addition to the farmer's own labor was $1000. It should last for sixty years more, or a total of one hundred years, surely not a very large yearly cost. There is no question in its owner's mind but what it paid him to build it, and he looks back upon his efforts with a great deal of justifiable pride and satisfaction.

He stated recently that, when they were building it, he was told by a neighbor that he was putting too much money into it, that he could raise just as good cattle in a straw shed as he could in that barn. "I told him," he proudly stated, "perhaps I could but I would not have nearly so much fun in doing my work." Forty years of history have proven the economics of this case as he still has his barn and the neighbor has nothing.

Storage buildings to hold surplus crops until they may be disposed of at proper prices are not only necessary but they are good investments. This was demonstrated about 1715 B.C. when Joseph's foresight in storing surpluses averted famine in Egypt and other countries. Fig. 7 shows a granary built fifty-six years ago and still in good condition. Grain stored in this building when prices were low and sold when prices were higher has paid its cost several times over. If farmers would hold their grain or hay on their own farms in times of surpluses or would purchase it from other farmers who were forced to sell at low prices, it would be a great help in standardizing and maintaining profitable prices for their products.

A good, vitrified clay block silo such as shown in Fig. 5, or one of reinforced concrete construction or good concrete staves, will last fifty to one hundred years. This makes a very low yearly cost and it is much more economical than the trench or temporary fencing silo particularly when the extra labor of filling, erecting, and feeding are considered as well as the waste from spoilage, and it is much more satisfactory to do farm work around well-constructed buildings.

In the United States we have now reached a period of time where it is possible and desirable to build farm structures of a substantial character having a life of 100 years or more. There are plenty of materials, money, and workers to do the job. The question arises therefore as to whether money should be borrowed, if necessary, for such a purpose, and if so, for how long a time should the loan be made, and at what rate of interest? Should we as agricultural engineers encourage farmers to borrow money for new buildings, and should we advise persons or organizations having money to invest, that investments in farms and farm buildings are highly desirable? If we are interested in farm life as a whole with good farm homes and equipment to make farm life enjoyable, our answer must certainly be "yes."

FIG. 5 (LEFT) THIS MODERN BARN AND SILO WILL LAST ONE HUNDRED YEARS. FIG. 6 (MIDDLE) A 40-YEAR-OLD BARN GOOD FOR SIXTY MORE YEARS. FIG. 7 (RIGHT) THIS GRANARY IS FIFTY-SIX YEARS OLD AND STILL GOOD

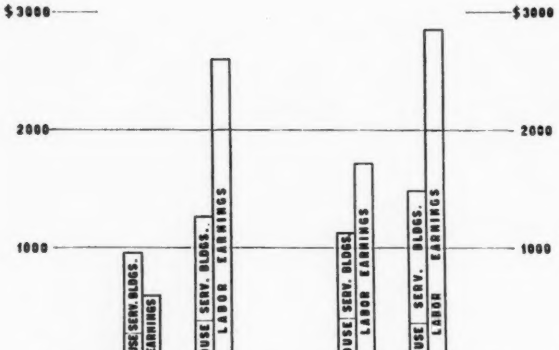


FIG. 8 GOOD BUILDINGS RETURN GREATER LABOR EARNINGS. THIS GRAPH SHOWS OPERATORS' LABOR EARNINGS AS RELATED TO ANNUAL COST OF SERVICE BUILDINGS AND HOUSES ON 40 MINNESOTA FARMS (1929)

Our answer must, of course, be based upon our knowledge of the individual farmer's or owner's circumstances. As a rule farmers may be divided into three general groups such as inefficient farmers, established farmers, and commercial farmers. The first group is comprised of those who lack experience, capital, machinery, and power; whose farm land may not be clear from debt. Possibly they do not like farming, but circumstances have placed them on farms. Many of this class no doubt would do better working for someone who owned a farm and could direct their efforts. Loans to this group should not be encouraged as it is doubtful if they could meet the competition from established farmers and repay the loans.

Established farmers are those who naturally like farming, have had experience, and have proved to be good managers. They own their land at least, have machinery and power with which to operate, and are accustomed to meeting their financial obligations when due. Their buildings may be in poor condition and need rebuilding. This group should be encouraged to build and financiers should extend to them long-time loans at very low rates of interest for building purposes in order to encourage their efforts and to provide normal employment for labor. It probably will not be possible for them to make sufficient profit to pay the entire loan in a few years, and if they will construct buildings that will last for 100 years, it should not be necessary for them to attempt to do so. This class of farmers make our best citizens. Their homes should have all of the conveniences of the city homes. There is no safer investment than reasonable loans to such farmers.

The third group, or commercial farmers, consist of those who secure possession of large tracts of land and attempt to farm for profit. Their own families as a rule live elsewhere, and the farm home life is not so desirable as that on the smaller well-established farm. When prices of farm products are high, they are induced to overproduce and increase the surpluses, and they are not able to continue in business when prices are low. I doubt if it is good practice to encourage such farming or advise loans to such enterprises.

It is of course obvious that it is impossible to make an economic analysis on farm buildings covering the past 100 years as the prices for farm products are not stable and data is not available for such a purpose. Neither is it possible to predict what the next 100 years will bring forth. However, we have had farm buildings for far more than 100 years, and we are safe in assuming that we will need them for at least that long in the future. Farm prices may go up or they may go down, but time goes on, and even if the world does go into a 600-year decline, some farmers will still be prosperous and happy during their lifetime of three score years and ten. They will be those who have a sound philosophy of life, do the best they can with what they have to do with, keeping faith, and using their talents. "For unto every one that hath shall be given, and he shall have abundance; but from him that hath not shall be taken away even that which he hath."

Some economic studies on buildings have been made by agricultural colleges, but as these have covered only a few years of time and have given but little consideration to the value of labor saving as well as the value of farm products, definite conclusions are very difficult to establish. At the University of Minnesota the Division of Agricultural Engineering and the Division of Agricultural Economics studied data covering a few years and found that on the forty farms covered in the study the twenty farms that had the best buildings made the largest labor earnings, which proves quite conclusively that adequate buildings are necessary in the farming business. Fig. 8 illustrates the comparative labor earnings on these particular farms.

It is highly desirable that much more extensive and definite research and study be made on farm structures problems. Agricultural engineering research and extension in our agricultural colleges should be reinforced, and county agents should be urged to give more time and effort to farm structures. County agents as a rule are selected for their knowledge of the production of crops and livestock, and they have little or no training in building problems. Observation of the last ten years of agricultural progress quite bears out this statement.

At the present time most of our established farmers are not able to build necessary buildings, neither are they able to repair, remodel, or paint their present buildings, and serious loss or unusual depreciation is taking place with but little hope of relief as higher prices are threatening to take place in all of their purchases. Our government in the past has always profited from assisting farmers to become established on homesteads, tree claims, etc., and it will again profit if it can find ways for universal help to honest and industrious farmers, and at the same time find employment for needy workers.

It must be recognized that it is not possible to make sufficient profit on farm products to pay for new buildings in a few years time, and to be profitable, buildings should be erected that will last over a long period of time, 50 to 100 years at least. This very often necessitates long-time, low-rate loans, possibly with renewal privileges. It is of course realized that many inefficient farmers will not be able to negotiate loans. They will benefit, however, by the rise in prices of their products, and they may be able to find extra work at good pay helping neighbor farmers who are able to build or repair their buildings.

Agricultural experiment stations and colleges should be requested to direct more of their energies and funds to agricultural engineering projects, such as farm improvements, buildings, fences, silos, water systems, drainage, soil erosion, etc., thus assisting in a consumption program as well as in a production program. They should also be urged to establish short courses in farm structures for the benefit of farmers and country builders, provide agricultural engineers as speakers for public meetings and furnish bulletins and building plans to farmers who contemplate building improvements.

Theory and Practice of Soil Sterilization[1]

By A. G. Newhall[2]

GROWERS of flowers and vegetables usually have one primary object in mind when they undertake soil sterilization. They are driven by the necessity of ridding their soil of its parasitic fungus flora, or of its disease-producing nematodes, its deleterious bacteria, vira and injurious insect pests[3]. Under the crowded conditions of the propagating bench, growers, in their well-intended efforts to maintain the optimum conditions of fertility and moisture, unwittingly establish the most favorable conditions for the multiplication of the many harmful parasitic, as well as useful, non-parasitic micro-organisms.

A very few of the most common pathogenes which force North American growers of vegetables and ornamentals to sterilize include species of the fungi *Pythium* and *Rhizoctonia,* the principal causes of damping-off of many seedlings and cuttings; *Fusarium, Verticillium,* and *Phytophthora,* the causes of important wilts and foot rots of tomatoes, cucumbers, asters, peonies, and tulips; and *Sclerotinia, Sclerotium, Botrytis, Thielavia,* and *Plasmodiophora,* commonly associated with root and stem rots of lettuce, narcissus, geranium, tobacco, and cabbage; and the root-knot nematode, *Heterodèra marioni,* which is by far the most important nemic parasite of vegetables and ornamentals with a host range of over three hundred kinds of plants. It alone is responsible for more steam soil sterilization than any other three organisms together. Several bacterial and even insect pests may attack specific crops and sometimes render sterilization imperative, such as *Aplanobacter michiganense,* the cause of tomato bacterial wilt, *Pseudomonas campestris,* causing black rot of cabbage, *Bacillus caratovorus,* causing the soft rot of a score of plants.

It should not be understood from the above that complete sterilization or the killing of all micro-organisms in the soil is aimed at in soil disinfestation work. Indeed complete sterilization is undesirable and may be temporarily harmful. The hosts of beneficial bacteria, fungi, nematodes, and animalculae which are continually at work breaking down organic substances and rendering their constituents available as plant food, and the nitrogen-fixing bacteria and ammonifying organisms are really the farmer's friends. What we are aiming at is what the English have correctly termed "partial sterilization." We want to leave as many useful micro-organisms in the soil as possible. Some useful organisms fortunately survive our present soil treatments due to their capacity to form resistant spores, and others quickly find their way back into the soil from the subsoil, the air, in water, on roots of transplants, tools, and shoes of workmen.

The chief secondary object of soil sterilization is the destruction of weed seeds. In hotbed and cold frame soil this is important enough sometimes to warrant the effort and expense even in the absence of the primary reason. Another secondary object which is frequently mentioned is increased fertility resulting in extra earliness. This is due in part to the destruction of root parasites and in part to the liberation of extra plant food and the changing of water-holding capacity about which more will be said later.

All soil treatments in use today may be grouped under one of two general headings—those involving the application of heat and those in which chemicals are added to the soil. Historically the application of heat is the oldest and even yet is the most important in this part of the world. The old Romans recognized the beneficial effects of fire on soils many centuries before the nature of plant diseases was discovered. This is noted in Virgil's Georgics. Italian writers of the latter part of the 19th century advocated burning over tobacco seedbeds to avoid loss from root rot which is known to be caused by the fungus *Thielavia basicola.* The early settlers in America also noted that their melon and pumpkin vines grew better where brush fires had occurred. And to this day in England the Warburton apparatus consists of a brick-lined trough in which "sick" soil is placed and under which a coal fire is kept burning day and night until the temperature of the soil is sufficiently high to warrant its removal and replacement.

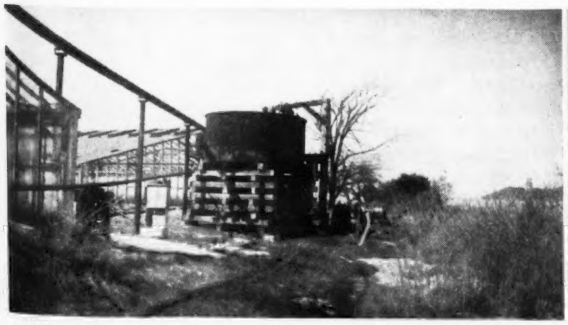
Chemical Disinfestation

Chemical methods of treating soil probably received their first impetus shortly after Pasteur in 1864 definitely quashed the theory of spontaneous generation and the

[1]Paper presented at a meeting of the North Atlantic Section of the American Society of Agricultural Engineers at Amherst, Massachusetts, October 1934.

[2]Research assistant professor of plant pathology, Cornell University.

[3]According to the 1930 census there are about 3,300 acres of vegetables and ornamentals grown under glass in the ten leading northern states. If we assume one fourth of this acreage is sterilized each year at an average cost of $500 an acre, we have an estimated sum of $400,000 spent annually for soil disinfestation. Some day a portion of this acreage may be sterilized by electricity.



(LEFT) A 3000-GAL TANK HOLDING ENOUGH DILUTE CARBON BISULFIDE EMULSION TO TREAT 3000 SQ FT OF GROUND BED. (RIGHT) THE SEMI-ANNUAL APPLICATION BY GRAVITY FOR NEMATODE CONTROL SHOULD BE MADE WHILE THE SOIL IS BEING SPADED OVER TO INSURE DEEP AND THOROUGH PENETRATION. (Photos by courtesy of E. F. Guba, Massachusetts Agricultural College

German chemist Hoffman three years later introduced to the world formaldehyde as a disinfectant.

The search for suitable chemical disinfestants for soil treatment has gone on almost incessantly for the past half century but the ideal one has not yet been found. Not many have survived the testing period and come into general use. There are several reasons for this. The ideal chemical should be effective against fungi, bacteria, nematodes, and insect pests if it is to compete successfully with steam. None is so effective at present. It should not be too expensive. This requirement alone rules out some of our most effective chemicals. It should not be dangerous or disagreeable for the uneducated laborer to handle indoors. Further, it should not leave a toxic residue in the soil for any great length of time. Most chemicals have to be applied in liquid solutions. To get them intimately mixed a good deal of labor is involved. Several days then have to elapse while the soil is drying out sufficiently to permit plant growth. With florists this delay is rather objectionable where soil is expected to be in almost continuous use.

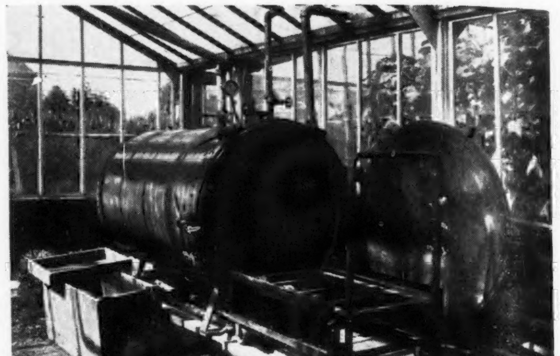
A great many men change their soil because they object to sterilizing with chemicals. But if they do not have a source of reliable new soil, they may be jumping from one frying pan into another because virgin soils often contain *Pythium* and *Rhizoctonia* and grubs and wire worms. Also the very size of some establishments precludes soil renewal very frequently. So with a certain number of growers sterilization must be done with chemicals or not at all. For such men formaldehyde solution made by mixing 1 gal of formaldehyde to 50 gal of water and used at the rate of ½ gal to the square foot still represents the most satisfactory chemical treatment against most soil pathogens. Formaldehyde is easy to obtain, mixes readily with water in all proportions, is a fairly good fungicide, and leaves no unfavorable residue in the soil for very long.

The disadvantages of formaldehyde are that it is not very effective against the root-knot nematode nor some of the sclerotia forming fungi such as *Botrytis* and *Sclerotium*, nor does it kill all weed seeds. Also it is very disagreeable to handle indoors and cannot be applied near living plants as the fumes are toxic to foliage. Furthermore, two weeks must elapse before treated soil can safely be used again. The cost of treating large areas with formaldehyde solution is between $400 and $500 an acre, or about 1 cent a square foot, which is close to the cost of steam sterilization. The latter is much more reliable and satisfactory in the long run.

Glacial acetic acid has been advocated as a cheaper substitute for formaldehyde. It is prepared by adding 1 gal to 99 gal of water and is used at ½ gal per square foot. It is less disagreeable to handle but otherwise has about the same limitations as formaldehyde. An even cheaper substitute in pyroligneous acid has been tested against damping-off organisms with only fair results when used in 3 or 4 per cent solution.

Carbon bisulfide has insecticidal and nemacidal properties and recently has been used in emulsified form in addition to formaldehyde to rid greenhouse soils of nematodes and fungi. This mixture is the nearest thing to a one-shot soil treatment for whatever may be present that can be recommended on experimental evidence today. Unfortunately the cost is altogether too high and the fumes of carbon bisulphide are not only inflammable but may cause illness or discomfort to the workers applying it, and furthermore it must be applied twice a year if tomatoes and cucumbers are being grown. This doubles the cost per year.

Corrosive sublimate solution made by dissolving one ounce of the powder in 10 to 15 gal of water has been successfully used for several years in cabbage and cauliflower and radish seedbeds to disinfest the soil of the fungi which cause wire stem and club root and the eggs and larvae of the cabbage maggot. The solution is poured along the row several times at weekly intervals as the seedlings emerge and develop. Mercury compounds, both organic and inorganic, have been successfully used for the control of root rots or crown rots of several ornamentals, and for the control of forest-nursery seedling diseases, as well as for brown patch of golf greens. The obvious objections to mercurial treatments are the expense, the danger from poisoning, and the possibility of cumulative toxic action from their repeated use in the same soils. Recently a severe blight of rose buds has been traced to volatile mercury vapor from treated soil. In fact, this last is one of the chief points against chemical treatments with metallic salts of any kind. This objection is most frequently voiced by the florist who wants to treat his cutting bench sand several times in a season.



A CANNER'S PRESSURE COOKER MAKES A GOOD STEAM STERILIZER BUT IS TOO EXPENSIVE FOR MOST GROWERS. (Courtesy of Ohio Agricultural Experiment Station)

It might be asked at this point why are chemicals used at all. The fact is that there has been no alternative for the grower who had no steaming equipment, except that of changing the soil. And for large establishments changing all the soil each year is hardly practicable, although some carnation growers do practice it on some of their beds.

Steam Sterilization Methods

Greenhouse growers in northern latitudes who operate under steam heat are not dependent on chemicals for soil disinfestation[4]. The first use of steam for commercial greenhouse soil sterilization seems to have been made in 1893 by W. H. Rudd in Greenwood, Illinois. He laid three steam pipes perforated at 18-in intervals in the bottom of a wooden bin 4½ ft deep and holding 480 cu ft of soil. A similar outfit in Ohio was used by a Mr. Lodder in 1896. Possibly the buried perforated pipe systems used now for so many years in the Ashtabula district of Ohio were a direct outgrowth of one of these. Instead of the soil being brought to the pipes, the latter are carried from place to place and repeatedly buried in the soil, where steam under pressure is liberated for one or two hours or until the soil for a depth of 10 to 20 in is all brought to a temperature of from 150 to 212 deg F.

Buried Perforated Pipe System. There is considerable leeway permissible in the specifications of a successful perforated pipe system. The individual pipes may be from

[4]In passing it should be mentioned that pots and small flats of soil can be disinfested by immersing them in boiling hot water for a few minutes. Even drenching ground beds with hot water is practiced in some ranges with partial success.

1 to 2 in in diameter, depending on their length. They may vary in length from 30 or 40 in up to 150 ft. The perforations, 1/8 to 3/16 in in diameter, are spaced 8 to 16 in apart and sometimes are staggered about 20 deg to the right and left of the bottom side. One end of each pipe is commonly bent (elbowed) to protrude above ground a foot and is provided with a union by which it is attached to a cross header. Usually a header supplies steam to a set of seven or eight pipes laid parallel 12 to 16 in apart and 8 to 12 in deep. The number and length of the pipes used will depend upon the size and shape of the ground beds to be treated, the capacity of the boiler, and the time of year when sterilizing is expected to be done. The depth of burial will be governed by the crops to be grown and the pests to be fought and the character of the soil. In general it is safe to plan to treat 2½ sq ft per boiler horsepower per hour on ordinary loam soil. Heavy clay requires more time than light sandy loam. From 1⅓ to 4 lb of coal may be used per square foot of ground bed steamed. This depends not only on the efficiency of the fireman and boiler, but on the depth of burial of the pipes, the moisture content of the soil, and the final temperature aimed at.

The water vaporized during steaming periods is astonishingly high. In a test on light sandy soil near Cleveland, where the pipes were buried only 8 in deep and the steamed area was only 3⅓ ft per boiler horsepower, during three one-hour steaming periods an average of 1.8 gal of water was vaporized per square foot of soil. Tests made with the buried-tile method, described later, showed that from 2 to 4 gal are commonly used with that system.

The buried-pipe method is very effective against such pathogens as root-knot nematode, *Fusarium*, and *Verticillium*, and does not require an excessive amount of expensive equipment.

To be more specific about costs, a convenient unit for a 100-hp boiler might consist of seven 1¼-in pipes each 40 ft long, fed by a 2-in header 8 ft long, and costing $75. Two such outfits are really needed, and when the necessary steam main and valves and hose connections are added; the cost may reach $200, which is comparable to the cost of a set of pans covering a similar area of 330 sq ft each hour. The pipe method sterilizes from 3 to 6 in deeper than the pan method in the same or a little longer time and uses a little more fuel for that reason. The labor required is also considerably more than that required in the pan system about to be described. A crew of from three to six men may be kept fairly busy with two sets of seven pipes, each set covering an area of 300 to 900 sq ft.

The Steam Pan System. The idea of inverting over the soil a large galvanized iron pan and forcing live steam under it and into the previously loosened earth, seems to have originated in the nineties with the Wutrick Brothers of Cleveland, Ohio, although the credit has been given to Dr. Shamel of the U. S. Department of Agriculture who employed the same method in 1904 to sterilize tobacco seedbeds in Connecticut.

The pan is rectangular, from 6 to 9 in deep, and may vary in size and shape to fit the width of the greenhouse or outdoor seedbed where it is to be used. A small one would cover 30 to 50 sq ft, while a large one might cover over 100 sq ft. They are often operated in sets of two or four covering the entire width of a greenhouse at one time. The pans are usually made of 20 or 22-gage galvanized iron. Sometimes heavier material is used for the sides than for the top. With 20-gage or lighter the rim should be reinforced with a thin piece of strap iron, leaving the edge as sharp as possible so that it can be forced into the ground. If 14-gage is used for the sides, extra reenforcing will not be needed. Suitable reinforcement of the pan with two-by-fours, angle irons, or pieces of gas pipe must be provided to insure rigidity. Handles are fastened on the two ends of smaller pans and at the four corners of larger, heavier ones. A notch is left in one side to permit entrance of the steam pipe, or a 1¼-in pipe is built into the pan with suitable union on the outside for connection with a flexible steam hose.

The weight of such a pan varies from 300 to 500 lb. Larger pans are heavier and are lifted by pulleys. A heavy pan is preferable to a light one, since steam under higher pressure to secure deeper penetration can be used without its lifting the pan off the ground. Weights such as concrete blocks, sacks of sand, or pieces of steel rail, are usually placed on the corners of the pan and soil is banked around the sides to help force the steam into the ground.

The cost of a set of four pans for a house 30 by 200 ft, if made by the local tinsmith, generally comes to approximately $100. This much again may be spent on pipe and valves, header, and steam hose. The pans should last from two to six years and the pipe much longer.

A number of improvements over the first simple two-men pans have been designed by ingenious growers. One is the Thompson one-man rolling pan which is really three pans put together in such a way that they may be rolled or pulled over with a block and tackle from the steamed to the unsteamed soil, so that the operator never has to walk on freshly treated soil.

Another improvement is the large Darrow hanging pan which is suspended from the hay track hangers that operate on angle-iron hay racks temporarily hung under the gutters of the greenhouse and extending from one end to the other. With four pans covering a total of 450 sq ft and operating on a 150-hp boiler with adequate leads, an acre can be steamed in 100 hr by only two men, leaving each pan in position 1 hr at a time.

The Miller one-man, underslung pan is another labor-saving device that makes use of concrete walks along the sides of the ground beds. A frame supporting a large heavy pan is mounted on wheels which run on the edges of these walks. The pan is raised and lowered by a crank operated by one man who easily rolls the 600-lb outfit to its new position every 30 to 60 mins.

Since the pan heats the soil to a shallower depth than either the buried-pipe or the buried-tile method, to be described next, it is evident that less coal is consumed per square foot treated and the cost per unit area is a little lower. In general, partial sterilization can be obtained at a depth of from 5 to 10 in, and one can treat 2.7 sq ft per hour per boiler horsepower by this method at a cost of from 0.6 to 1.2 cents per square foot.

The pan system is as widely used as the buried perforated pipe but is less effective at depths greater than 6 or 7 in. This means that when nematodes and *Fusarium* or *Verticillium* are being fought and high-temperature crops are to be grown, such as cucumber and tomato, the pan method sometimes fails to give control for the entire year following. Growers have been swinging over therefore in increasing numbers to the most effective and most easily operated system of soil disinfestation yet devised for the treatment of ground beds, namely the buried-tile system.

The Buried-Tile System. This method of sterilizing employs either 3 or 4-in drain tile which are laid 12 to 16 in deep in rows 18 or 20 in apart. Steam is admitted under pressure through a system of headers and close-fitting nipples which feed several lines of tile at one time.

There is much leeway permissible in the matters of shape and size of a unit area. The size is somewhat limited by the size of the boiler of course. From 6 to 12 sq ft of

soil per boiler horsepower can be successfully steamed at a time, although the area treated per hour is not as large (1.3) as in the other two methods. Larger areas are not recommended.

A single header can take care of almost any number of tile lines from one or two up to forty or more, the number depending almost entirely upon the width of the greenhouse or individual bed to be steamed. Many greenhouses are 30 ft wide. If a boiler of 100 hp capacity is available, the width can very properly be divided into two or four-unit areas depending upon the length of the house, keeping in mind the fact that steam even under a boiler pressure of 80 to 100 lb should not be expected to travel more than 100 ft through cold lines of tile, if quick results and a minimum of condensation troubles are desired. In this connection, if the lines must slope, it is best to introduce the steam at the upper ends to avoid pounding and broken tiles.

The cost of installation is greatly influenced by the distance between the lines of tile. Lines spaced greater than 22 in apart are rarely satisfactory if nematodes and *Fusarium* wilts are being fought. On the other hand, 12-in widths are unnecessary in any but the heaviest soils. In most soils 18 in on centers represents a very satisfactory compromise. The depth may properly vary in accordance with the width but need not be much greater than will insure safety in plowing, which is 13 or 14 in to the bottom of the trench. Of course the soil line will be raised an inch or so by the laying of tile.

The cost of installing an acre of tile in lines 12, 18, and 24-in apart and 11, 15, and 18 in deep, respectively, were found by the author to be approximately $2200, $1800, and $1500, respectively, for tile and labor in a sandy loam soil. Other workers have given similar estimates varying between $1400 and $3200 where lines were 3 ft to 14 in apart, so that a round figure of $2000 per acre is not far off. A good man can lay 400 to 500 tile a day, if the soil is not too heavy, which at a $3 wage scale is about 0.6 cent per tile. An acre of tile, or 30,000 at $25 per 1000, will cost $750 plus hauling charge[5]. This brings the cost of laying the tile to about $1000 when lines are 18 in apart. To this must be added the cost of pipe for mains and secondary leads, the necessary valves, headers, and other accessories, besides the labor of cutting, threading, and installing these items.

The interest on an investment of $2000 is $120 a year which must be added to the annual charge for fuel of say $350 (70 tons at $5), bringing the annual charge for steaming close to $500 an acre. It should be remembered, however, that the cost for fuel is a similar charge for any type of steam sterilizing, so that in comparing the cost of the different methods the principal items to compare are the interest on investment in the tile method with the labor costs of the other two methods. Some hothouse vegetable growers are willing enough to have their men employed through the slack season to use one of the more laborious methods of sterilizing.

While a set of pans or of buried pipes may last from two to six years, buried-tile systems have been in use for 15 to 18 years. Not infrequently a few tile will have to be replaced if heavy horses or tractors are used for plowing.

Helpful Hints in Steaming Soils. It is important to have the soil loose and fairly dry for most satisfactory penetration. This is particularly true in the pan system. A soil containing 60 per cent of moisture takes twice as many Btu (British thermal units) as one with only 20 per cent because the specific heat of water is three to four times as great as that of mineral soil.

A good covering for the areas that are being steamed should be provided to reduce heat losses to a minimum. Heavy building paper, tarpaulins, boards, burlap, and old canvas sails have all been used. A tough mulching paper is quite satisfactory for long narrow beds. Anything impregnated with creosote of course should be avoided.

The size of all mains and leads and headers should be large enough so that the maximum volume of steam which the boiler can safely furnish can be quickly put into the soil. Recent one-acre installations have been employing 4-in mains and 3-in leads and headers throughout. It is the steam delivered through the header that counts rather than the pressure on the boiler. Increasing the size of pipe from 1 to 2 in increases the flow of steam approximately four times at normal steaming pressures. Also increasing the pressure from 10 up to 100 lb increases the flow about four times. It is an excellent idea to have a pressure gage on the header. This will indicate how much longer to steam areas more distant from the boiler to get equally good results.

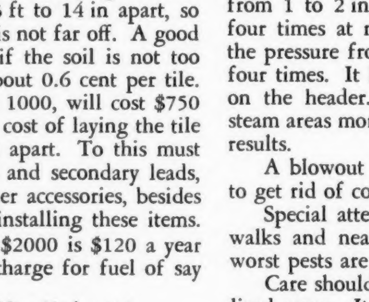
A blowout assembly or by-pass at the header is useful to get rid of condensate before each morning's run.

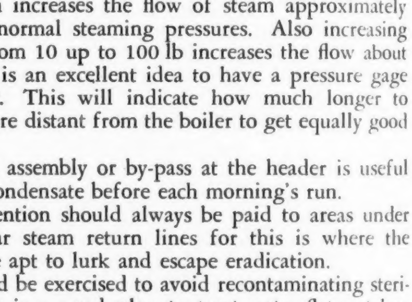
Special attention should always be paid to areas under walks and near steam return lines for this is where the worst pests are apt to lurk and escape eradication.

Care should be exercised to avoid recontaminating sterilized areas. It is a good plan to treat pots, flats, stakes,

[5]Price of car lots delivered in western New York 1934.

A—REAR VIEW OF A 2⅓-CU-FT OHIO OR RESISTANCE TYPE STERILIZER WITH HORIZONTAL ELECTRODES TOP AND BOTTOM, DESIGNED TO OPERATE ON 230-VOLT CIRCUITS. CONNECTED LOAD VARIABLE. B—A 5-CU-FT NEW YORK OR HEATING ELEMENT TYPE STERILIZER DESIGNED TO OPERATE ON 115 OR 230-VOLT CIRCUITS. CONNECTED LOAD 1600 WATTS





walks, and tools with a good disinfectant like formaldehyde at the time the ground is being sterilized.

Physical, Chemical, and Biological Effects of Heating Soil. When soil is heated to the boiling point or above, or even treated with chemicals there are times when rather marked changes seem to take place. One of these, a physical change, is that the water-retaining capacity is very much reduced. Gifford has shown that capillary water can not rise nearly as high or as rapidly in sterilized soils, perhaps due to destruction of colloidal films connecting the soil particles. Growers find that such soil requires more frequent watering, and that it take less water at a time to saturate the soil. Tomato plants were found by Smith to wilt less readily in steamed soil and to absorb nearly twice as much water as they did from unsteamed soil. The plants also transpired more water in steamed soil. The osmotic pressure of the steamed soil was greater as indicated by a reduction in its freezing point.

Besides breaking down the soil colloids, moist heat is believed to alter the soil chemically by dissolving salts present inside the soil particles. On drying these salts are deposited on the surface of the soil particles and are therefore more readily brought into solution. Thus an excess of soluble salts may temporarily follow a very thorough heating of a potentially rich soil. Nitrites and ammonia are particularly increased, and in many heated soils ammonium carbonate has been thought chiefly responsible for the temporary retarding effect on the growth of seedlings which has sometimes been observed. Very recently at the Boyce Thompson Institute, McCool has shown that the proportions of soluble manganese may increase very materially on heating mineral soils. These may become somewhat detrimental to plant growth for a few weeks. Increases in total soluble salt content of from two to ten times the original amount present have been recorded occasionally in very rich soils. Fortunately excess soluble salt content can usually be quickly and easily removed by thoroughly soaking or leaching the ground. This is where a tile system becomes doubly useful in removing this excess, salt-laden moisture.

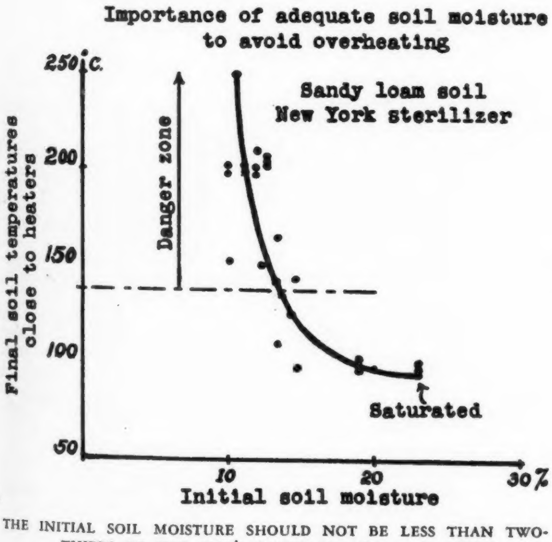
Biological effects resulted from soil sterilization may be very marked especially in highly organic soils. Sackett and others have shown that both the nitrogen-fixing bacteria, as represented by *Ozotobacter,* and the nitrifying bacteria, *Nitrosomonas* and *Nitrobacter,* are killed by ordinary steaming. These bacteria can be found again in such soil after a period of several weeks. The ammonifying bacteria, on the other hand, are largely spore formers and so can survive the treatment. As soon as the soil cools these ammonifiers start converting the organic matter into ammonia which may pile up temporarily in excess in the absence of nitrifying bacteria to convert it into nitrites and nitrates. It is held by some that protozoa which feed on the bacteria can survive partial sterilization also and become very numerous after such treatment, resulting in a wholesale destruction of the few beneficial bacteria that may have survived or that soon trickle in again.

Electric Soil Sterilization

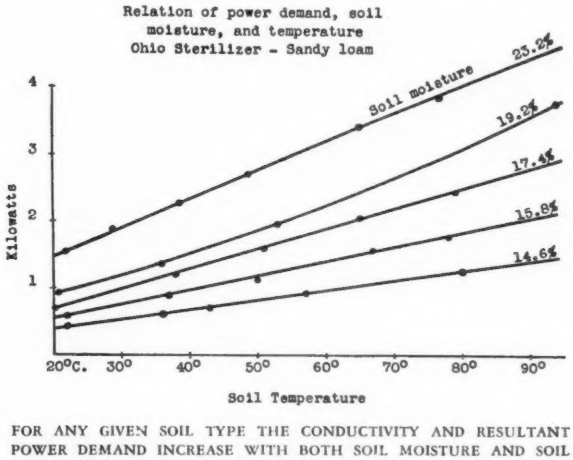
Now that electricity has come into its own and can be had for less than ever before and is being used in some way by a great majority of the greenhouse growers of the country, interest naturally centers in the practicability of electric soil sterilization. The mere question of the possibility of such a method has already been answered in the affirmative by the early work of several men. Chief of these should be mentioned D. E. Blandy and L. B. Carney of the New York Power and Light Company, M. W. Nixon of the Empire State Gas and Electric Association, J. C. Scott of the Puget Sound Power and Light Company, A. V. Krewatch and G. W. Kable working under the National Rural Electric Project, and I. P. Blauser of the agricultural engineering department of Ohio State University.

The necessary pioneering work on the engineering side of the problem having been done, it has seemed desirable at Cornell University to make a study of the relative efficiency of the two general methods so far proposed with reference to their ability to kill some of the soil pathogenes commonly met with in cutting bench sand, in loam top soil, and in muckland seedbeds. We also wanted to find out what the optimum moisture content is for most efficient sterilization of each type of soil. This project was entered into jointly in the summer of 1934 by the Departments of Plant Pathology and Agricultural Engineering at Cornell and the research engineering division of the Empire State Gas and Electric Association, and is being financed in part by a grant from the latter association.

For these studies four electric sterilizers were put under test. They ranged in capacity from 1 to 5 cu ft. Two were of the heating element or indirect heating type already on the market in New York state, and two were of the soil-



THE INITIAL SOIL MOISTURE SHOULD NOT BE LESS THAN TWO-THIRDS OF THE SOIL'S WATER-HOLDING CAPACITY



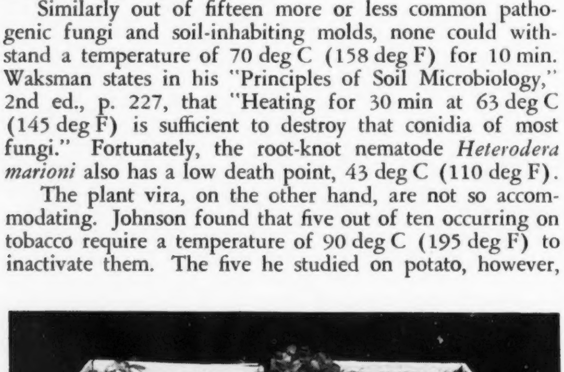
FOR ANY GIVEN SOIL TYPE THE CONDUCTIVITY AND RESULTANT POWER DEMAND INCREASE WITH BOTH SOIL MOISTURE AND SOIL TEMPERATURE. THESE RELATIONSHIPS ARE LEAST NOTICEABLE IN PURE WASHED SAND, AND MOST PRONOUNCED IN SOILS OF HIGH ORGANIC CONTENT

resistance or direct heating type advocated in the far west and in Ohio. Soil was moistened, thoroughly shoveled over, placed in the sterilizers, and raised to a certain predetermined temperature. A sample was withheld for moisture determination. The current consumed was always metered, and at the end of the run temperature readings were taken at from twenty to thirty places in the soil mass. Sometimes soil was obtained from growers over the state who were having damping-off troubles or root rots. At other times pure cultures of various organisms were buried in several places in the soil mass and after the run were recovered and tested for viability by plating out on standard agar media under asceptic conditions. Since all parts of the soil mass did not ordinarily heat up to the same temperature in a given length of time, opportunity to obtain data on the thermal death point of several organisms was afforded.

In general these data have corroborated the scattered information gleaned from the literature and indicating that practically all of the parasitic bacteria, fungi, nematodes vira, and probably insects which may occur in soils may be killed at temperatures considerably below the boiling point of water. For example, out of ninety-two bacterial plant pathogenes whose thermal death points in water for 10 min have been recorded in the literature, seventy-eight fall between 46 and 56 deg C (115 and 133 deg F). Only four can withstand 60 deg C (140 deg F), the highest temperature being 68 deg C (155 deg F).

Similarly out of fifteen more or less common pathogenic fungi and soil-inhabiting molds, none could withstand a temperature of 70 deg C (158 deg F) for 10 min. Waksman states in his "Principles of Soil Microbiology," 2nd ed., p. 227, that "Heating for 30 min at 63 deg C (145 deg F) is sufficient to destroy that conidia of most fungi." Fortunately, the root-knot nematode *Heterodera marioni* also has a low death point, 43 deg C (110 deg F).

The plant vira, on the other hand, are not so accommodating. Johnson found that five out of ten occurring on tobacco require a temperature of 90 deg C (195 deg F) to inactivate them. The five he studied on potato, however,



RESULTS OF ELECTRIC STERILIZERS OF A COMMERCIAL FLORIST'S SAND AS MEASURED BY THE RELATIVE NUMBER OF HEALTHY SEEDLINGS OF CUCUMBERS, SPINACH, TOMATO, AND GYPSOPHILA TWELVE DAYS AFTER SOWING. UNTREATED SOIL IN FLAT ON LEFT. (IN THE CHART, SEEDLING GERMINATION IN UNTREATED SOIL IS REPRESENTED BY THE SOLID PORTION, AND IN STERILIZED SOIL BY THE OUTLINED PORTION)

all could be inactivated at temperatures below 70 deg C (158 deg F).

Fortunately many insects and their eggs are also readily killed by temperatures considerably below the boiling point. When one considers that the thermal death point usually refers to a ten-minute emersion and that soil heated electrically takes one to six hours to reach the end-point, there seems to be a reasonable margin of safety in this fact alone. Of course, it is most essential that an adequate supply of moisture be present for low temperature killing. All organisms are very much more resistant to dry heat than to moist heat.

With sterilizers employing pipe-type space heaters for the source of heat, all three types of soil, e.g., muck, sand, and clay loam, were successfully disinfested. It was very important that soils high in organic matter have sufficient moisture to avoid burning of the soil in contact with the heaters. In fact, the best results were obtained usually when the soil moisture was just a little higher than would be considered optimum for best plant growth. This meant for sand, 6 to 8 per cent; for loam, 18 to 24 per cent, and for muck, 120 to 150 per cent, on the dry-weight basis.

With the resistance type of sterilizer occasionally a sand was obtained that had such a high resistance that an electrolyte had to be added to dilute solution before sufficient current would pass through to raise the temperature in a reasonable length of time.

Cost of Electric Soil Treatments. One burning question is everyone's mind at present regarding electrical soil disinfestation is the matter of expense. This we have paid particular attention to by having a meter on all of our tests which now number over one hundred. The current consumed of course varies with the threshold temperature and soil moisture and the final temperature attained. But, in general, it can be stated that, starting at room temperature, any soil that is not completely saturated can be heated up to 70 deg C (158 deg F) with from 1 to 2 kwh (kilowatt-hours) of current per cubic foot. If the current cost is set at 3 cents per kwh, the cost of disinfestation then varies between 3 and 6 cents per cubic foot. A cubic foot will ordinarily fill between three and four average sized flats.

Limited experiments with soil in cutting benches indicate that ordinary soil-heating cable can not profitably be used to sterilize soil as it will not stand the required high temperatures. When large enough quantities of cable are distributed in the soil to raise it to the desired temperature without injury to the cable, the expense is prohibitive.

But there is some evidence indicating the feasibility of using a set of pipe-space heaters in cutting benches, moving them every few hours similar to the way buried perforated steam pipes are handled.

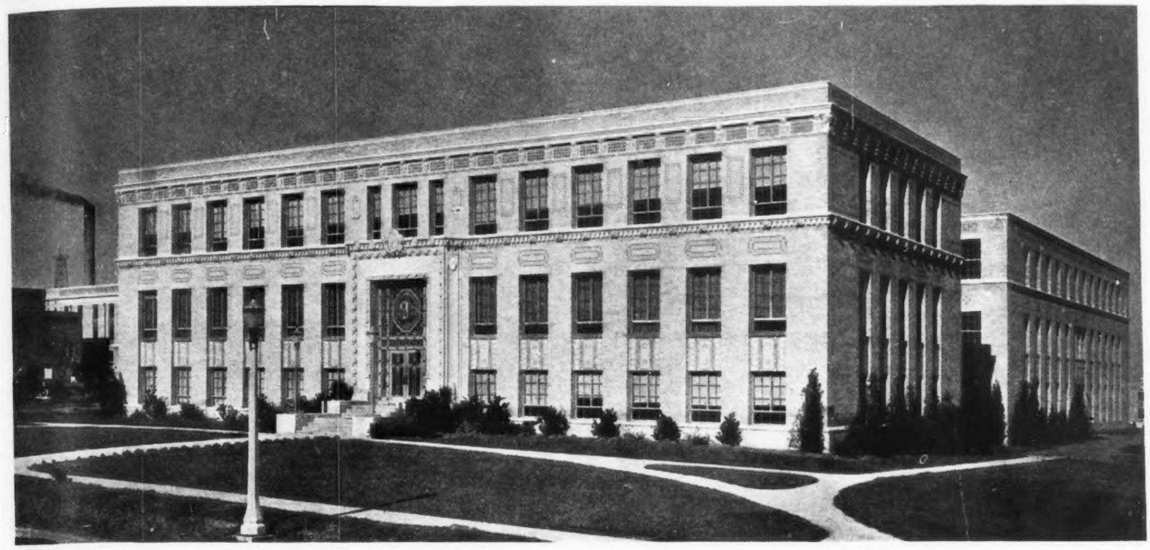
We have reason to believe that the field of electric soil sterilization has a rather bright outlook and will doubtless yield to further experimentation considerable of value to both the grower of plants and the producer of electricity.

Corrections

THE AUTHOR of the article, entitled "Some Requirements for Extending Farm Electrification," on page 415 of the December 1934 AGRICULTURAL ENGINEERING, calls attention to an error just discovered in the original manuscript of this paper. Near the bottom of the first column on page 416, reference is made to Governor Ehringhaus of Connecticut, the state name should have been North Carolina.

* * * *

The attention of readers is called to a typographical error in the name of one of the authors of the paper, entitled "A New Type of Terracing Machine," on page 6 of the January 1935 AGRICULTURAL ENGINEERING. The correct name is Q. C. Ayres—not W. C. Ayres.



THE NEW $200,000 AGRICULTURAL ENGINEERING BUILDING AT THE A. AND M. COLLEGE OF TEXAS

Texas Agricultural Engineering Building a Modernized Classic

By Margaret King[1]

A DEFINITION of agricultral engineering and a delineation of its possibilities are written into the very framework of the new Agricultural Engineering Building at the A. and M. College of Texas at College Station. Two hundred thousand dollars worth of building materials and inspiration went into the construction of this stately milestone in the history of agricultural engineering in Texas. Modernized classic in style, it has reinforced concrete frame with brick walls. The floors throughout are concrete with those in the offices, classrooms, and corridors being laid with terrazzo. The building contains 10,000 sq ft less than two acres of space and is divided into two sections with a lecture room between. This lecture room separates the office-classroom section from the laboratory section and serves to keep the noise of the engines and machines in the laboratories from the offices and classrooms.

The September 1933 AGRICULTURAL ENGINEERING carried the story and an illustration of the entrance and front doors of this building. The entire facade of the building is ornamented with Spanish tile in six different special designs representing various phases of agricultural engineering. This variegated tile adds local color to the interpretation of the universal appeal of the profession.

The front section of the building covers 18,824 sq ft and is three stories high. The ground floors contain offices for graduate students, store rooms, a rural electrification laboratory, and an irrigation and drainage laboratory. The latter is 1066 sq ft in size and is equipped with sand and soil tables with outlets for water, in order that drainage and irrigation problems may be worked out and tested under conditions similar to those in the field.

[1]Secretary to head of agricultural engineering department, A. & M. College of Texas.

On this floor also is an exhibit foyer, supplemental to the foyer on the floor above, running almost the entire length of the building, on which is displayed new equipment coming to the department, such as cutaway models of recent automobiles, farm machinery, tractors, and other machinery of especial interest to the students and visitors.

The second floor is the main floor with offices for the head of the department and the professors, as well as the secretary and graduate assistants. The library and conference rooms are on this floor, as is also a small drawing room for the use of the staff. The main exhibit foyer is on this floor. Black marble walls, terrazzo floors, fantastically decorated ceiling with special hand-wrought troughs for indirect lighting makes this an ideal place for the display of modern equipment, and it is a rare hour that does not find an inquiring student or an interested farmer inspecting the machinery that is shown. In the corners of this foyer are niches designed to hold the busts of famous agricultural engineers and spaces for plaques are provided around the walls as another means of doing honor to the pioneers of the profession. Panels are provided for murals showing the development of agricultural engineering which will, it is hoped, be provided later.

There is a hydraulic elevator from the ground floor to the second floor on which display pieces can be brought up. This not only facilitates the placing and removing of equipment, but also minimizes the danger of marring or damaging the machinery or the building in the process.

The library with its long study table and comfortable chairs invites the student to peruse the books that line its walls. These books, ancient and modern, American and foreign, are the foundation of a comprehensive collection of the worthwhile publications on agricultural engineering subjects and are the source of many interesting and valuable sidelights on the work.

The office of Mr. Scoates, head of the department, is the architectural gem of the building, so far as interior decoration is concerned. It is panelled in yellow pine and the beautiful effect obtained is a tribute to the artist who saw in native materials the beauty that would have been evident to a stranger and less "contemptuous" eye. The ceiling of soundproof material is painted to make it a colorful part of the entire design. Hand-wrought light fixtures and leather-covered doors add to the beauty of the room, while the built-in book cases strike a note of utility without failing to be decorative. Fireproof filing vaults are adjacent to the office of the head of the department and also to that of the departmental secretary.

The lecture room is the show place of the building. It has a seating capacity of 120. The seats are arranged in rising tiers and enable every occupant of the room to see the lecturer. There is a circular platform, 16 ft in diameter, in the center of the front of the room. This platform can be raised five feet by hydraulic power and can be revolved. A large door in the rear of the room can be raised to allow for the moving of any piece of equipment or machinery from the laboratories onto the platform where it can be raised to the required height and seen by every member of the class. Spotlights are trained on this platform for use in night lectures. There is a silver screen on the rear door which can be used for showing motion pictures. Heavy draperies at doors and windows can be draw to make the room lightproof for this same purpose. The ceiling has been treated accoustically, and the speaker can be heard at any place in the room without having to raise his voice. This ceiling has been painted in silver and blue and green in a lovely design and suspended in the center of it is a most unique chandelier. It is composed of a wagon wheel and decorated with harrow teeth, shovels, disks, trace chains, and the various parts of farm machinery. The most interesting thing about it is that it is so lovely as to allay all suspicion as to its utilitarian origin. People come and admire it and go their way without even knowing that it is a wagon wheel—unless their attention is called to the fact. A modern and efficient ventilator enables the occupants of the lecture room to breathe clean, fresh air at all times.

On the third floor of the front section of the building are the classrooms. There are four light, comfortable rooms, each equipped with a spacious closet for books and equipment. One of the large classrooms is furnished with shades that darken it sufficiently for the showing of motion pictures. A drafting room containing 990 sq ft is on this floor, as well as a blueprinting room with drainage pans already installed. There is also a private laboratory for the head of the department with woodworking and other modern equipment which enables him to work out many of the interesting problems connected with agricultuaral engineering and the teaching of it.

The farm buildings laboratory extends from the front section of the building to the laboratory section and is the same size and directly above the lecture room. In this laboratory are models of farm buildings of all kinds, as well as farm equipment. The fundamentals of design and construction are set forth in visible form in this laboratory.

The rear or laboratory section of the building covers 14,592 sq ft and is the site of all the practice classes. All the floors in this section are of concrete.

The farm shop on the first floor contains 4,391 sq ft of space. It is equipped for wood work, concrete work, forge work, metal work, rope work, and all types of repair work on the farm from reroofing buildings and wiring the farm home, to sharpening tools and repairing implements. The woodworking section of the shop has a wooden floor laid over the concrete but the other half of the room has a concrete floor. Tool cabinets are built around the wall and there are built-in bins for concrete, sand, gravel, coal, and sawdust. Electrical machinery, modern equipment, and up-to-date tools make for efficient work in this shop. Adjoining the farm shop at one end is a classroom with a seating capacity of 20. At the other end of the shop is a store room for paints, nails, lumber, and so forth, which obviates the waste of time incident to going back and forth for materials.

THE UNIQUE CHANDELIER IN THE LECTURE ROOM OF TEXAS AGRICULTURAL ENGINEERING BUILDING

There is a large farm machinery laboratory the entire length of the first floor in the center of the building. From it machinery can be taken into the lecture room or to any other part of the laboratory section. At the rear of this laboratory is a two-story section with a chain hoist with a capacity of five tons. This hoist is used in assembling heavy pieces of machinery. This large, double-story section of the laboratory is used to house a combined harvester-thresher and other large machines.

On the first floor is an experimental laboratory, 17 by 34 ft, assigned to the agricultural engineering division of the Texas Agricultural Experiment Station, where machines are built and tested.

The trucks owned by the department are housed in the building in a truck storage room where they are also repaired and serviced. Adjoining this garage section is the tractor and automobile laboratory, 72 by 44 ft, where old and new models of automobiles and trucks and tractors are on display. Many of these are cutaway models that allow the students to study the intricate mechanisms.

There is a freight elevator from the first to the third floor of the laboratory section. It has a capacity of five tons and is large enough to accomodate any piece of equipment that is received, or a truck loaded with machinery.

A circular iron stair also goes from the first to the third floor of the laboratory section and proves to be a very expedient means of going from one floor to the other.

The second floor of the laboratory section is the site of the gas engine laboratory, 63 by 42 ft. This laboratory is equipped with specially designed iron bases to which the

engines are bolted, from which special pipes carry the exhaust to the roof. A special laboratory classroom, as well as a parts room, adjoin the laboratory.

The farm home convenience laboratory, 37 by 45 ft, is a point of interest because it is here that the students study the construction, operation, and repair of individual water, lighting, and power plants. Everything from plumbing fixtures, refrigeration systems, and stoves to windmills and heating systems is studied in this room.

The machine shop, 18½ by 36½ ft, is not usually open to the general public. It is here that the members of the staff find a special place to build, care for, and repair machinery and apparatus equipment of the department.

There are, on the second floor, store rooms for oil and gas, as well as for paints, lumber, and spare machinery parts.

The remainder of the floor, 4441 sq ft, is occupied by a farm machinery laboratory, with all types of power, horse-drawn or hand-operated machinery.

The entire third floor is given over to farm machinery—14,592 square feet of well-lighted, well-ventilated, fireproof display room filled with up-to-date equipment that is a mine of information and inspiration, not only to students in the department, but to every visitor. There is a parts room on this floor with bins and shelves that solve, as nearly as possible, the tedious problem of keeping at hand the spare parts and accessories to all the machinery on display.

Such is the new agricultural engineering building at the A. and M. College of Texas—modern, efficient, and attractive. It is kept open at all times to anyone who cares to inspect the equipment. Guests come from all walks of life—minister, farmer, editor, manufacturer, homemaker, teacher, lawmaker, and all the rest. Each leaves something of his spirit of seeking for knowledge and faith in his job, and the staff trusts that each takes with him an inspiration to do his work better and some bit of information or knowledge gained—else the "bird of wisdom" that hovers over the building (120 times duplicated) shall forsake us for another resting place.

New Things in Household Equipment[1]

By Evelyn H. Roberts[2]

THE COMMITTEE on Electric Equipment for the Farm Home of the ASAE plans to develop a set of standards of performance for household equipment this year. Each member of the Committee is to work on some particular piece of equipment, their proposed standards to be studied and criticised by the group and other workers in the field. Another activity will be to develop uniform test methods for equipment. The list of active projects and completed reports will also be kept up to date.

A new type of coal stove, developed under Swedish patents, is on the market in the eastern states to compete with gas and electric stoves. This stove, which is heavily insulated, is rated as 80 per cent efficient. It burns 1½ tons of anthracite coal per year, operates automatically except for one filling of coal daily (8 to 10 lb), and offers varied cooking temperatures. A small fire heats a massive barrel which is kept at high temperature by draft control. Heat from this barrel is conducted and radiated to the other parts of the stove. The left surface plate is very hot for fast cooking, the right plate is at simmering temperatures. The upper oven is very hot, while the lower one is for low-temperature baking. A special set of cast aluminum utensils, designed with very flat bottoms, are supplied with the stove. While the initial cost of the stove is high, in comparison to the average insulated stove, the operating cost is very low.

House Heating with Electricity

The contractor's camp at Grand Coulee Dam in Washington is today a laboratroy for extensive experiments in heating houses electrically. Three and four-room houses, prefabricated, are set up ready for occupancy in three days' time. Electric heaters, ranging from 1.5 to 5.0 kw, will be used to heat the various rooms. Electric water heaters and ranges are also supplied each house. The annual cost of electricity for heating, lighting, and cooking will lie between $60 and $75.

Adequate insulation in walls, floors, ceilings, and roofs of houses should permit of satisfactory heating by radiant electric units. One experiment on heat storage consists of heating a special oven full of boulders during the night hours, the stored heat in turn heating the house during the daytime. This and other experimental studies with different types and design of insulation are being directed by engineers from the State College of Washington.

[1]A review of recent developments in household equipment especially suitable for farm homes, contributed by the ASAE Committee on Electric Equipment for the Farm Home, of which the author is chairman.

[2]Research specialist in home economics, State College of Washington. Assoc. Mem. ASAE.

About Terrace Maintenance

IF FARMERS will see to it that terrace lines are properly laid out and terraces constructed to proper height and base, little work will be required each year to maintain and to keep them in good shape, says C. E. Ramser of the USDA Bureau of Agricultural Engineering. Farmers who carefully maintain their terraced areas annually receive the greatest returns on the investment.

During the first year for best results the newly-built terraces should not be cultivated, but should be seeded to cover crops. After heavy rains it is a good plan to look over the terraces, especially at weak places, for breaks which can be repaired immediately. After the first year, when plowing the fields it is best to throw the soil toward the terrace embankment from both sides. Turning the soil toward the embankment helps maintain the height and broadens the base of the terraces.

Breaks at bends are caused by water washing against the terraces and cutting through the embankments and usually occur where the terraces have considerable grade and the water a high velocity. Seeding the terraces at bends helps to prevent breaks.

Breaks at crossing of gullies or draws are usually caused by failure to build the tops of terraces to proper heights across such places or by failure to make proper allowances for settlement of terraces. The grade of the top of a terrace leading into a gully crossing never should be greater, and preferably less, than the grade of the top leading out, because with a greater grade above more water is brought into this section of the terrace channel than can be carried out on the lighter grade below.

STUDENT ACTIVITIES

Contributed and edited by members of ASAE student branches

The Farm Equipment Institute Cup

By Lester Malkerson (Minn. '35)
President Agricultural Engineering Students' Conference

HERE IS THE NEWS we have been waiting to give the various ASAE student branches! Here is your opportunity to win a large silver trophy for your branch!

We have been very fortunate in having a cup donated to us by the Farm Equipment Institute of Chicago. The cup is to be known as the "Farm Equipment Institute Cup," and will be awarded to the student branch showing the greatest activity during the year. The branch to receive the cup will be chosen by a special committee appointed by the President of the Society, which will include also a representative of the Farm Equipment Institute.

The awarding of the cup will be made largely on the basis of letters received by the committee from the various student branches. The letters will contain information relative to the activities of the branch and will be made up in accord with instructions from the committee of judges. The judges will be instructed to give the award to the branch that does the most effective work during the year. Further details will be given out from the Secretary's office later.

The committee after choosing the winner will notify the branch, and a student representative of the student branch to receive the cup will probably be required to be present at the annual meeting in June, if that branch is to get the award. Any branch that wins the cup three years in succession may keep the cup permanently.

Contacts

IT HAS BEEN SAID that the contacts made by business concerns is the oil that helps that business to function. This also is true of individuals. Generally speaking, the more contacts a young man can make, the greater will be his chances of establishing himself with a reputable concern. Even in these days of slack employment, concerns are looking for men to replace their depleted ranks. With this in view, students should grasp every available opportunity to make these contacts.

Next June, the ASAE will hold its annual meeting at Athens, Georgia. The student organization has worked out a program that will be of interest to all. Representatives of various commercial firms are to speak at the student meeting. The speakers will talk on how to apply for a job and what commercial concerns expect of graduate engineers. There are ten men on the program. Each one will speak for a period of fifteen to twenty minutes. After each talk, the meeting will be open for discussion, and the students may ask the speaker questions pertaining to his subject.

This meeting will be beneficial to all students who can attend, not only in the contacts that will be made, but in the helpful advice that will be given by these men who have been "through the mill,' so to speak.

If you possibly can attend, it will be well worth your time and money. Now is the time to start your plans. Probably some student in your branch has an old Ford. Why don't four or five of you "chip in" and drive to the meeting? It will not cost much.—LESTER MALKERSON.

News of the Georgia Branch

THE FIRST MEETING was opened by an address of welcome by Prof. R. H. Driftmier, head of the department of agricultural engineering, University of Georgia. He discussed the bright future of agricultural engineering and welcomed the 28 freshmen into the branch pointing out the large increase over last year's enrollment. The feature talk of the evening was given by Prof. U. H. Davenport on a trip that he took through the Northwest last summer.

At the next meeting Prof. W. N. Danner gave a talk on the ASAE annual national meeting which he and Prof. Driftmier attended in Detroit last June.

Prof. Crabb, who is on leave from the college of agriculture and connected with the USDI Soil Erosion Service, gave us our third lecture. He spoke on soil erosion, its effect and control.

A special meeting was called on November 19 for Prof. R. U. Blasingame, head of the agricultural engineering department at Pennsylvania State College, who brought the branch a message of good will from the Penn State branch, and gave a lecture on improvements made on corn and Irish potato cultural methods by Penn State.

Dean Paul W. Chapman, of the college of agriculture, gave the branch a talk on employment, the New Deal, and the future of agricultural engineering at the fourth regular meeting.

On December 8 the branch gave a dance, members of other college clubs were invited, and the faculty acted as chaperons. A picture of the members of the branch and their dates was taken for their annual, "The Georgia Ag Engineer."

The last meeting of the year was held on December 10. Mr. Lov E. Rast, director of the Sandy Creek Soil Erosion Project, gave the branch a very interesting talk on soil erosion.

A Message from Your Vice-President

WE'RE ALL surely keenly interested in learning of all the fine things the different student branches of ASAE are doing. However, I'm sorry to say that there are still a couple of our branches that have failed to get on the "band wagon." Now I know they are just as interested as the rest of us in the activities of the others, so I wish, if any of you reading this message know your branch isn't in with us, will you please urge them to come along? Let's make our page in the March Journal 100 per cent. That is, let's have something from every one of the twelve branches of the United States. Address all news to Charles Schlotterbeck, Agricultural Engineering Dept., Ohio State University, Columbus.

News of the Oregon Branch

VERY SOON after school started our branch organized and constructed an exhibit that was on display in a prominent place for a week at the Pacific International Livestock Exposition at Portland. The exhibit showed different phases of work carried on by the USDI Soil Erosion Service at the Pullman, Washington, project. This subject is of particular interest to us here as all of our 1934 graduates and nearly all of the juniors worked on that project during the past summer. Incidentally, we have five 1934 graduates with permanent positions in the SES.

Every year our branch gives some sort of reception to our new students, both freshmen and transfers. The reception this year took the form of a campfire evening in the park. Upper classmen took charge and attended to every detail, even to bringing the guests to the location and taking them home. Our entire program lasted only an hour or so as we believe in making things very short and peppy. After hot dogs, buns, and coffee, introduction of everyone and the program followed, which included welcome to our club, and an outline of the organization of our club and its objectives. We strive to make newcomers welcome and feel at home as quickly as possible They return this consideration in taking an active part in the club work right away. The reception went over in a big way.

On Sunday, December 3, the freshmen and other new students gave upperclassmen and faculty a breakfast in a downtown hotel. This was a showing of appreciation of work of upperclassmen in publishing our magazine last spring, the "Agricultural Engineer." The program included musical numbers by the men, report of soil erosion work at Pullman, Washington, and faculty and student speeches.

Our club has completed two land clearing jobs this fall term. With the Caterpillar "Diesel" 35 loaned to our department, the new students have earned quite a bit of money pulling trees in old orchards and have gotten valuable experience in diesel operation. (*Continued on page* 76)

NEWS

Plans for the 1935 ASAE Annual Meeting

PRELIMINARY PLANS for the 29th annual meeting of the American Society of Agricultural Engineers have been announced by Chas. E. Seitz, chairman of the Meetings Committee of the Society, following a meeting of the Committee at Atlanta, Georgia, January 30 and 31.

The annual meeting this year, as previously announced, will be held at the University of Georgia, Athens, with members of the agricultural engineering staff of that institution and the Southern Section as joint hosts. Subject to final approval by the Council of the Society, the tentative dates for the meeting are June 17 to 20, inclusive.

The first day, Monday, June 17, will be devoted exclusively to group meetings, principal of which will be the College Division of the Society and the Agricultural Engineering Students' Conference, both of which will be all-day sessions. Other groups may arrange special conferences or meetings on this day by arrangement with the Meetings Committee.

The annual meeting will be formally opened on the forenoon of Tuesday, June 18, with an address of welcome by one of the executive heads of University of Georgia, which will be followed by the annual address of the President of the Society—this year Glen W. McCuen, professor and head of the agricultural engineering department, Ohio State University. Invitations are being issued to two prominent leaders in the present federal administration at Washington to address the meeting on subjects of timely interest to agricultural engineers; one of these speakers will be scheduled for this session. It is also planned, at this session, to have a paper on the rural rehabilitation work that is being carried on by federal government in cooperation with the states.

The afternoon of the same day is to be devoted to an inspection tour of soil erosion control projects of particular interest to agricultural engineers in the vicinity of Athens. The evening of the same day will be devoted to entertainment, also to meetings of committees and other groups.

Like the forenoon of the previous day, the morning session of Wednesday, June 19, will be devoted to a general program featuring prepared papers devoted to most recent developments or other matters of timely and vital interest in the four main branches of agricultural engineering, namely, soil erosion control, rural electrification, farm structures, and farm power and machinery. Also, another address by a distinguished representative of the federal administration is tentatively scheduled for this session.

The afternoon of the same day will be devoted to sessions of the Society's four technical divisions. The annual dinner which is the high point in ASAE annual meetings will be held on the evening of the same day.

The annual business meeting of the Society will be held early on the forenoon of Thursday, June 20, after which the four technical divisions will go into session for the rest of the day followed by an evening of entertainment.

Two optional inspection tours are being planned for Friday and Saturday, June 21 and 22, for those interested in visiting points of special agricultural engineering interest in the South. One of these tours will include in its itinerary a visit to the rural organized industrial community at Warm Springs, Georgia, and to the Alabama agricultural experiment station at Auburn, famous for its research in agricultural engineering. The return trip from this tour will be via the Norris Dam development of the Tennessee Valley Authority.

A shorter tour following the meeting will be to go direct from Athens to the Norris Dam project, where it is believed members will have an opportunity to see some of the interesting developments which the Tennessee Valley Authority is carrying on of special interest to agricultural engineers.

Details of the program and other plans for the Society's 1935 annual meeting will appear regularly in these columns each month, and also in special letters to the Society membership.

Pacific Coast Section Plans

AT A MEETING of the executive committee of the Pacific Coast Section of the American Society of Agricultural Engineers held recently, it was decided that the next meeting of the Section would be held April 12 and 13 at Porterville, California. The subjects tentatively agreed upon at that time for the program include overhead sprinkling, soil surveys as an inventory of soil resources, effect on erosion of burning brush and grass from grazing lands, general aspects of erosion on agricultural lands, water requirements of citrus fruits, water requirements of cotton, air agitators for frost prevention, equipment for leaf hopper control on grapes, and gas engines for irrigation pumping.

Other features of the meeting will be an inspection trip to an overhead sprinkling installation and a dinner meeting at which moving pictures of construction progress on Boulder Dam will be shown.

It was also tentatively agreed upon at the meeting of the executive committee that a meeting in the fall should be held at Davis, California, to be devoted primarily to farm machinery and mechanical equipment.

* * * *

The Pacific Coast Section at its meeting at Corvallis, Oregon, reported in the January issue, passed the following resolution of interest to the agricultural engineering profession:

WHEREAS the low-water flow of the major streams of the West is dependent on the snow cover in the high mountain watersheds, and

WHEREAS foreknowledge of low-water flow would be of great assistance in planning farm operations, the operation of irrigation and power storage reservoirs, and for flood control and flood damage abatement, and

WHEREAS it has been demonstrated in several localities that snow surveys can be used in predicting low-water flow, and

WHEREAS general application of the snow-survey method waits upon a coordination of the results secured in these several localities by a national organization having the personnel and equipment required to make the necessary field and office studies, therefore, be it

RESOLVED by the Pacific Coast Section of the American Society of Agricultural Engineers that the Secretary of Agriculture in cooperation with appropriate agencies be requested and empowered to make comprehensive snow surveys in the several western states together with adequate studies of the methods and equipment.

Progress in FHA Farm Section

UNDER general guidance of its chief, Mr. Walter G. Ward, borrowed from his duties as extension architect of Kansas State College, the farm section of the Federal Housing Administration has completed its temporary field organization. This includes 24 farm representatives, one to three of which are assigned to each of the twelve regions into which the country is divided for purposes of administration. During the first half of January all of these men were called to Washington for special training.

An attractively printed, abundantly illustrated thirty-page booklet in bulletin size has been issued under the title "Open this Door to Farm Property Improvement." It is both promotional and informational in purpose, indicating the many forms of farm improvement eligible under the FHA, and pointing the way to contact with local cooperating agencies. The desirability of expert counsel is emphasized, and agricultural engineers are mentioned in this connection.

ASAE membership is well represented in the regional appointments, as well as by Mr. Ward himself. They include A. M. Goodman, extension professor of rural engineering, Cornell University, for New York; V. R. Hillman, assistant agricultural engineer, Virginia Polytechnic Institute, for Virginia and Maryland; George Nutt, associate professor of agricultural engineering, Clemson College, for North and South Carolina; Earl D. Anderson, Iowa Farmers' Mutual Reinsurance Assn., Grinnell, Iowa; H. F. McColly, associate professor of agricultural engineering, North Dakota Agricultural College, for North and South Dakota and Montana; C. V. Phagan, assistant extension agricultural engineer, Oklahoma

A. and M. College, for Oklahoma and New Mexico; and W. J. Gilmore, professor of agricultural engineering, Oregon State Agricultural College, for Oregon, Idaho, and Washington.

In general these and others of the regional representatives have been loaned to the FHA by their institutions. Their familiarity not only with territorial conditions and requirements, but with the plans and other buildings service available through the state colleges and experiment stations, not to mention extension and other cooperating personnel, should add much to the efficiency and despatch of the FHA farm program.

Personals

G. M. Clarke has been appointed assistant to the chief engineer (in charge of equipment) of the Soil Erosion Service, U. S. Department of the Interior. His address is 721 Sheridan Street, N.W., Washington, D. C.

Paul W. Jenicek recently assumed the duties of engineering-foreman on ECW project, PE-243 at Cawker City, Kansas. This position is similar to one he previously held at Jerseyville, Illinois.

Carl R. Olson has been appointed an assistant regional director of the Soil Erosion Service, U. S. Department of the Interior. His field of activity covers the S.E.S. soil erosion control projects in the Illinois area. He was formerly agricultural engineer for the Estate of Hiram Sibley.

Walter G. Ward is on six-months' leave from his regular work as extension architect at the Kansas State College, to devote full time to the promotion of the FHA program as it applies to farm conditions. He was recently appointed chief of the Farm Section of the Federal Housing Administration. During the period of his appointment he will be stationed at Washington.

New ASAE Members

D. D. Dhanda, state service assistant agricultural engineer, Western Circle, Aligarh, U. P. India.

Marion Eugene Ensminger, erosion specialist, Soil Erosion Service, U. S. Department of the Interior. (Mail) LeRoy, Ill.

Orvis R. Myers, graduate assistant, department of agricultural engineering, Pennsylvania State College, State College, Pa. (Mail) Patterson Hall, Room No. 1.

Martin Ronning, engineer, Minneapolis-Moline Power Implement Co., Minneapolis, Minn.

Applicants for Membership

The following is a list of applicants for membership in the American Society of Agricultural Engineers received since the publication of the January issue of AGRICULTURAL ENGINEERING. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

William P. Blum, Pacific Coast sales representative, Louden Machinery Company. (Mail) 472 Tehama St., San Francisco, Calif.

Parks B. Chappell, junior agricultural engineer, Soil Erosion Service, U. S. Department of the Interior. (Mail) Drawer 250, Spartanburg, S. C.

Clarence C. Chronic, chief engineer, Stover Mfg. & Engine Co., Freeport, Ill.

W. B. Denyes, chief engineer, Eastern Steel Products, Ltd., Preston, Ont., Canada.

Frank A. Donaldson, general manager, Donaldson Company, Inc., 666 Pelham St., St. Paul, Minn.

John M. Downing, agricultural engineer, Soil Erosion Service, U. S. Department of the Interior. (Mail) Rock Hill, S. C.

E. E. Epting, agricultural aide, Soil Erosion Service, U. S. Department of the Interior. (Mail) Box 897, Rock Hill, S. C.

W. R. Friberg, draftsman, Soil Erosion Service, U. S. Department of the Interior. (Mail) 309 Howard St., Pullman, Wash.

Karl Harris, agent irrigation assisant, division of irrigation, Bureau of Agricultural Engineering, U. S. Department of Agriculture. (Mail) 313 N. Third Ave., Phoenix, Ariz.

W. F. Hereth, Northwest Soil Erosion Service. (Mail) 217 N. Almon St., Moscow, Idaho.

Roy C. Ingersoll, President, Ingersoll Steel & Disc Co., 310 S. Michigan Ave., Chicago, Ill.

Mercer Lee, branch manager, International Harvester Co. of America, 580 Whitehall St., Atlanta, Ga.

C. W. McKnight, Secretary, Andelot, Inc. (Mail) Box 118, Fairfield, Conn.

G. A. Meares, assistant agricultural engineer, Soil Erosion Service, U. S. Department of the Interior. (Mail) 42 N. Main St., Greer, S. C.

W. H. Mikell, Jr., agricultural aide, Soil Erosion Service, U. S. Department of the Interior. (Mail) Rock Hill, S. C.

R. A. Owen, Soil Erosion Service, U. S. Department of the Interior. (Mail) 142 Oakland Ave., Spartanburg, S. C.

V. S. Peterson, chief technician and acting director 15 (Iowa) ECW camps. (Mail) 225 Gym Ave., Ames, Iowa.

Fred A. Thompson, Jr., junior agricultural engineer, Soil Erosion Service, U. S. Department of the Interior. (Mail) Drawer No. 250, Spartansburg, S. C.

H. Lee Vanderwilt, salesman-collector, John Deere Plow So. (Mail) 15 Highland Ave., Houlton, Me.

Franklin H. Watson, Jr., agriculturist, East Bay Municipal Utility District. (Mail) Box 61, Lodi, Calif.

Russell Woodburn, assistant agricultural engineer, Soil Erosion Service, U. S. Department of the Interior. (Mail) Spartanburg, S. C.

Student Activities

(Continued from page 74)

A stunt started this summer which turned out very well was a news letter. It is just a rambling collection of gossip, news, announcements and so on, which has very little style, but it certainly does the work. It keeps everyone in touch with the department and with each other all summer. Each student writes in his bit of news which will appear in the next issue. I was up in the Idaho mountains all summer and I certainly enjoyed receiving those newsy letters. —DONALD F. ROBINSON, *Scribe.*

News of the VPI Branch

THE PROGRAM of the ASAE student branch at Virginia Polytechnic Institute for the first quarter was successfully completed, the activities having been quite numerous.

Moving pictures of great educational value were presented at the meeting on November 22. They consisted of two reels, entitled, "The Refining of Gasoline," and two reels entitled, "Soil Erosion." The pictures dealing with soil erosion were of especial interest because of the fact that a large number of VPI graduates enter that field. On December 6 the branch sponsored a lecture and demonstration given by the Appalachian Power Company dealing with the relation of light to sight. It involved an explanation of the new science of seeing. It was a most interesting presentation and was enjoyed by students, faculty, and townspeople.

The activities of the fall quarter were concluded with a social held December 13. The sophomore members were in charge of the program, which featured a talk given by Prof. C. R. Baldock of the physics department. The subject of his talk was "Heavy Water," and it represented the results of his own research and that of others also. Refreshments and cigarettes were served.

The branch held its first regular meeting of the second quarter on January 3. The plans for the quarter were discussed. It was decided to hold a smoker the following Thursday and to make a special effort to secure the attendance of all freshmen enrolled in agricultural engineering.

The speaker for the smoker was Prof. Chas. E. Seitz, head of the agricultural engineering department, who gave a most interesting talk on the possibilities for agricultural engineers. Refreshments and cigarettes were served.

On January 17, a meeting was held in conjunction with the various engineering societies on the campus. The chief feature of the program was a lecture presented by Dean Earl B. Norris of the school of engineering, entitled, "Getting a Job."

Subsequent meetings will be devoted chiefly to talks to be given by members of the branch.—J. L. CALHOUN, *Scribe.*

News from Penn State

MEMBERS of the student branch of the American Society of Agricultural Engineers at Pennsylvania State College attended the Pennsylvania Farm Show at Harrisburg on January 21. The students devoted most of their time to visiting the various exhibits and observing the farm machinery and meeting the representatives in charge. In the evening they heard John M. McKee, executive secretary of the Pennsylvania Rural Electrification Commission, speak at a dinner at the Y.M.C.A.

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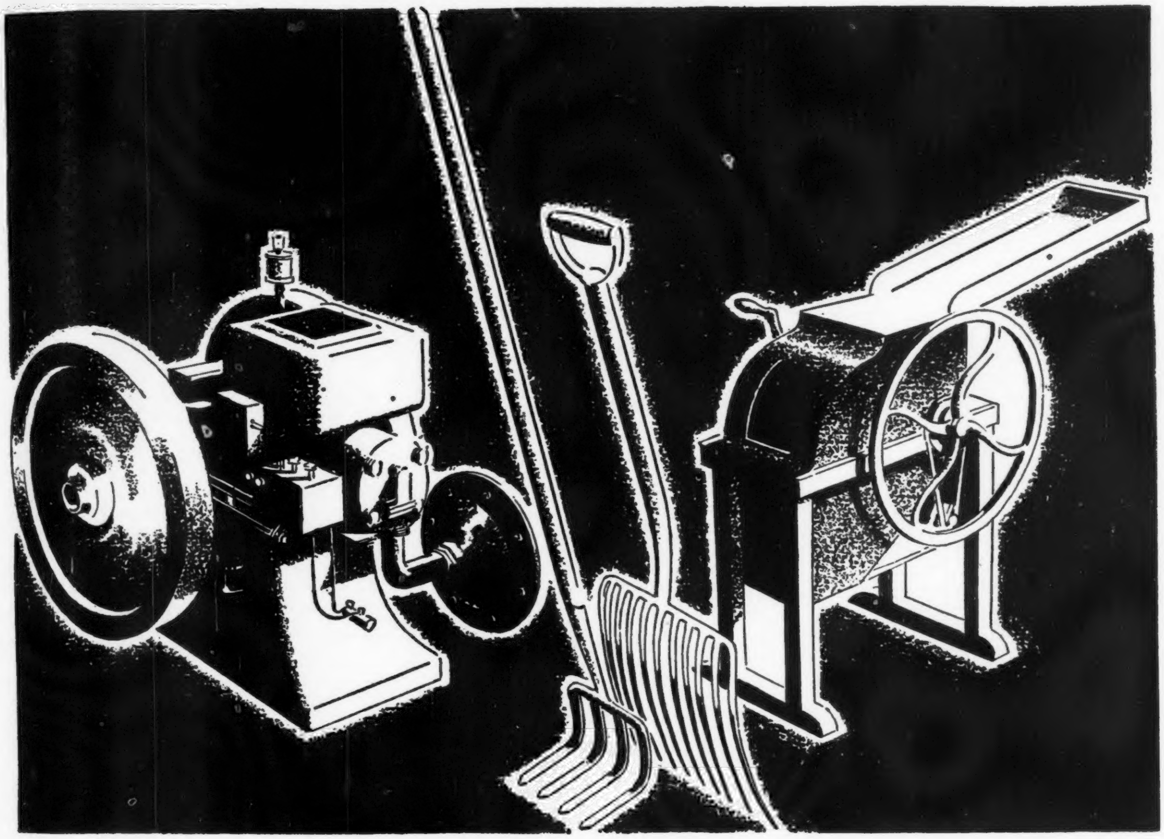

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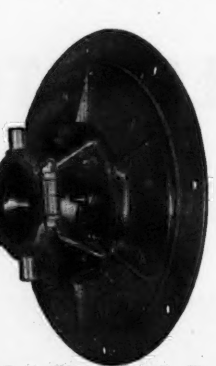

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Agricultural Engineering Digest

A review of current literature by R. W. TRULLINGER, senior agricultural engineer, Office of Experiment Stations, U. S. Department of Agriculture.

A PROGRESS REPORT OF INVESTIGATIONS OF THE VARIOUS USES OF ELECTRICITY ON THE FARMS OF WASHINGTON FOR THE YEAR 1933, *L. J. Smith* and *H. L. Garver*. (Pullman) Wash. Com. Relat. Elect. Agr., 1933, pp. 42, figs. 9. This progress report presents data and information secured during the year from studies of water heating for dairy stock, potato and root washers, apple washers, evaporation of irrigation water, pasture irrigation, and miscellaneous studies relating to water heating, ultraviolet radiations on apple grafts, and the like.

In the studies on water heating for dairy stock, tests made during the winter with 18 cows showed no increase in milk production, due to the warming of the drinking water. This was true with both high and low producers. Apparently there is no advantage in warming the drinking water unless it is more economical to supply enough heat to keep the trough free of ice than to take the ice off three or four times daily.

In the pasture irrigation experiments it was found that irrigation is valuable in bringing on new pasture and in bringing back pasture that has been partially winter-killed. It tends to reduce the percentage of weeds and helps fall pasture growth. Labor was found to be often the most expensive item in the cost of putting the water on the land. For practical and economical pasture irrigation the land must have uniform slopes and the volume of the water should not be too small. Apparently there is no advantage to be gained from overirrigation.

LARGE RETAINING-WALL TESTS (II. Pressure of saturated sand), *K. Terzaghi*. (Engin. News-Rec., 112 (1934), no. 8, pp. 259-262, figs. 4. This is the second contribution to the subject, in which studies are reported dealing with the results of investigations of cohesionless sand in a state of complete submergence.

It was found that the lateral pressure exerted by the submerged backfill is equal to the sum of the full water pressure and the lateral pressure of the solid fraction of the fill whose effective weight is reduced by buoyancy. The presence of the water has practically no effect on the coefficients of internal friction and wall friction. For a position of the wall in the immediate vicinity of the original one, the drainage of the fill produced a slight decrease of the hydrostatic pressure ratio, k, and an increase of the coefficient of wall friction, tan δ. During a subsequent intermission, k increased and tan δ became smaller.

In contrast to this, after the wall moved beyond an average distance of 1/1000 the depth of the backfill, drainage produced an important increase of k and a decrease of the wall friction, tan δ. During the subsequent intermission k became smaller, and tan δ greater.

Submergence causes a minute expansion, and drainage a more important subsidence of the fill. If the wall is close to its original position, the subsidence due to drainage is smaller than it is for more advanced positions of the wall.

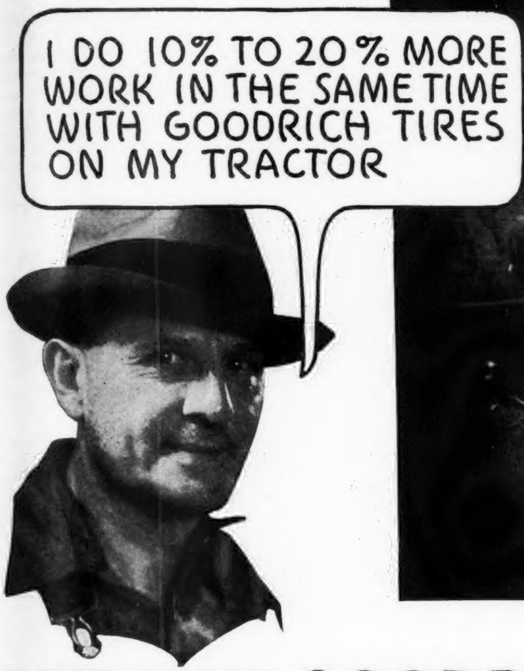
The tests furnished indirect evidence for assuming that prior to slip the lower part of the back of the wall experiences lower pressure than the middle part, provided the wall is backfilled with compacted material.

LARGE RETAINING-WALL TESTS (III. Action of water pressure on fine-grained soils), *K. Terzaghi*. Engin. News-Rec., 112 (1934), no. 10, pp. 316-318, figs. 4. This is the third contribution to the subject. The results show that, as with submerged sand, the retaining wall backfilled with fine-grained soil such as till or clay receives full water pressure plus the pressure of the solid fraction of the fill.

RAISING THE SOIL TEMPERATURE IN GLASSHOUSES, *W. F. Bewley*. Jour. Min. Agr. (Gt. Brit.), 40 (1934), no. 11, pp. 1047-1056. The results of experiments on heating glasshouse soils by electricity and hot water are summarized. These covered a period of several years and resulted in the extensive development of the hot water method as being cheaper and just as satisfactory as the electrical method.

The results showed, in general, that when the soil temperature is raised to 80 deg F during the first three months of the season, there is a definite improvement in the tomato crop. Root development is greater, and the roots are cleaner than in soil at ordinary temperatures. Vegetative growth is more vigorous and the plants remain green and healthy beyond the time at which they are usually removed. The first box of fruit is not usually picked earlier, but the main crop ripens more quickly and a greater weight is picked during the first month. With cucumbers, heavier and earlier crops have been obtained.

Much of the root trouble, which has *(Continued on page 84)*



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Agricultural Engineering Digest

(Continued from page 82)

made soil sterilization so necessary, is the result of unsuitable physical and chemical conditions. These appear to be overcome by increasing the soil temperature. On the other hand, some diseases would not be affected, while eelworm attack, which thrives under hot dry conditions, might be expected to become more serious.

The necessary apparatus includes (1) a hot water boiler for providing water at a temperature of about 140 deg, (2) an electric pump with starting device controlled by a soil thermostat, and (3) a quantity of one-inch pipe. The pipe, which should be specially treated to prolong its life in the soil, should be buried 2 ft below the surface in tomato houses and placed so that the lengths are 2 ft apart.

VEGETABLE CARBURANTS [trans. title], *A. C. Roux.* Rev. Internatl. Prod. Colon., 7 (1932), no. 84, pp. 369-416, pls. 10, figs. 2. Studies of African fuels and carburants of vegetable origin indicated the possibility of obtaining solid, liquid, and gaseous fuels by the use solely of raw plant materials yielding alcohol and oil. Tests of oleaginous seeds and nuts showed that all these materials yield a crude gasoline at low temperature carbonization. From this material light and heavy spirits, lamp oil, gas oil, and fuel oil can be extracted. Ammonia also is present in the residual liquids.

THE PRESSURE ON RETAINING WALLS, *C. F. Jenkin.* Inst. Civ. Engin. (London), Minutes Proc., 234 (1931-32), pt. 2, pp. 103-223, figs. 57. This paper, which is a contribution from Oxford University, describes the latest design used in experimental apparatus for testing the pressure on retaining walls and gives the results of a large number of measurements of the pressure exerted by sand on walls of several different shapes. A revised wedge theory is developed which explains the observed phenomena, and practical working rules are given for calculating the forces.

CARBURANTS CONTAINING A HIGH PERCENTAGE OF ALCOHOL [trans. title], *S. Doldi.* Gior. Chim. Indus. ed Appl., 15 (1933), no. 12, pp. 593-598, figs. 4. An account is given of a thermal process whereby it is possible to produce an internal-combustion engine fuel containing a high percentage of alcohol and which may be used directly in a common gasoline engine. Data are given on the physical and chemical characteristics of such fuels and of their value as compared with gasoline. These fuels consist of mixtures of methanol or ethanol with benzol in proportions containing up to 74 per cent of the alcohol. In certain proportions the mixed alcohol fuel has been found to have a volumetric efficiency equal to that of gasoline but the calorofic value of the gasoline is considerably higher. The temperature of the exhaust gases of the high alcohol mixture is higher than those of gasoline. Apparently the mixture containing 32 per cent alcohol and 68 per cent benzol has about the limiting proportion of alcohol for gasoline engines of normal compression ratios.

A STUDY OF THE SCREW-HOLDING PROPERTIES OF WOOD, *R. A. Cockrell.* N. Y. State Col. Forestry, Syracuse Univ., Tech. Pub. 44 (1933), pp. 28, figs. 3. Studies are reported the purpose of which was to determine to what extent variations in the structure and physical characteristics of wood influence its screw-holding power. Several kinds of wood of commercial importance were used including sugar maple, beech, birch, red oak, black ash, red pine, red spruce, hemlock, white pine, and basswood. The standard flathead type of screw was selected for the investigation. Three sizes were chosen, namely, 1-in No. 6, No. 8, and No. 10.

It was found that the woods may be listed in order of their screw-holding strengths, as follows: Maple, beech, birch, red oak, black ash, red pine, hemlock, spruce, white pine, and basswood. In a general sense the specific gravity of wood can be used as an index of screw-holding ability since the screw-holding strength varies within narrow limits as the first power of the density. There is considerable variation in screw-holding power in woods of almost equal density which must be due to inherent qualities of individual species. When wood is dried from above the fiber saturation point to 7 per cent moisture content, an average increase in screw-holding strength of 50 per cent was noted. This is only one-third to one-quarter of the increase in most other strength properties for the same change in moisture content.

In general, diffuse-porous hardwoods, especially those of high density, and conifers of irregular growth and uneven texture are stronger in screw-holding power from their tangential surfaces while ring-porous hardwoods and conifers of regular growth and fairly even texture are stronger from their radial surfaces. The average holding strength of dry wood in end-grain pulling was 65 per cent of the side-grain values.

The strength values for small size screws extracted from the radial surface of a ring-porous wood presented a much greater range of values than those extracted from a uniformly textured wood. Ring-porous woods are less desir- *(Continued on page 86)*

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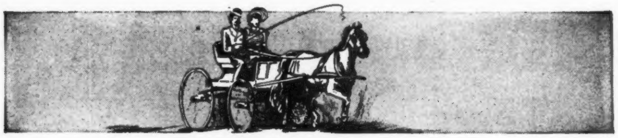

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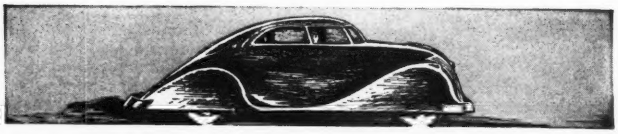

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Agricultural Engineering Digest

(Continued from page 84)

able for application necessitating strong screw-holding ability than diffuse-porous woods of approximately the same density. Other conditions remaining constant, a screw can be unscrewed from wood and replaced in its original lead hole with no loss of holding power. In making use of screw-holding values, a factor of safety of two should be the absolute minimum employed. The average resistance of wood to a force applied laterally to a screw is about 100 per cent greater than its resistance to the axial withdrawal. The quality of side-hardness appears to be more closely related to screw-holding ability than any other strength property of wood.

RESULTS OF LEVEL TERRACING ON HEAVY SILT LOAM SOIL, H. H. Finnell. (Oklahoma) Panhandle Sta., Panhandle Bul. 53 (1934), pp. 12. This bulletin embodies a summary of general observations previously reported and a preliminary report on the results of different terracing spaces observed over the period 1930-33.

A total grain yield increase of 32.6 per cent secured by terraces over the 8-year period 1926-33 was recorded on heavy silt loam soil at Goodwell, Okla., under a normal rainfall of 17.8 in. The land on which these results were obtained has a natural slope of 1 per cent or less.

That the increased yields were due entirely to additional moisture supplies provided by saving of runoff is indicated both by the increased soil moisture supply observed under terraced conditions and by the correspondence of yield increases to the amount of runoff liability experiences in the different seasons.

The yield results of different terrace spacings indicated more frequent terraces were required on the heavy soils to obtain a given moisture using efficiency than on lighter types of the same slope, and probably that contour listing would be required to get the maximum results in connection with terracing.

AGRICULTURAL ENGINEERING INVESTIGATIONS AT THE IOWA STATION, *J. B. Davidson, E. V. Collins, W. G. Murray, H. Giese, H. J. Barre, S. H. McCrory, R. B. Gray, C. K. Shedd,* and *I. E. Melhus.* Iowa Sta. Rpt. 1933, pp. 20-23, fig. 1. The progress results are presented of an economic and engineering study of corn production methods in Iowa, and of studies of farm building losses due to wind and fire, the all masonry barn, the use of tractors, tractor wheel efficiency, and the development of equipment for checkrowing beets.

PROPERTIES OF WHITE FIR AND THEIR RELATION TO THE MANUFACTURE AND USES OF THE WOOD, *R. P. A. Johnson* and *M. R. Brundage.* U. S. Dept. Agr., Tech. Bul. 408 (1934), pp. 77, pls. 10, figs. 31. This bulletin, prepared in cooperation with the California Experiment Station and the University of Wisconsin, furnishes detailed information on the properties and characteristics of the wood of white fir for use in determining the suitability of this wood for specific use.

AGRICULTURAL ENGINEERING INVESTIGATIONS AT THE LOUISIANA STATION. Louisiana Sta. (Bien.) Rpt. 1932-33, pp. 9, 10. The progress results of investigations are presented on artificial hay drying and the development of tillage machinery for corn and soybean production.

THE COMPUTATION OF ACREAGE UNDER PRODUCTION-CONTROL CONTRACTS, *S. P. Lyle,* U. S. Dept. Agr., Agr. Adjust. Admin., Wheat Sect., 1934, pp. [2] + 14, figs. 5. Practical instructions are given to aid in the rapid and accurate measurement of field areas.

Literature Received

LUMBER GRADE-USE GUIDE. The National Lumber Manufacturers Association, 1337 Connecticut Avenue, Washington, D. C. Complete $1.50. Printed in convenient loose-leaf form, this book is a compilation of data arranged in separate assemblies or pamphlets. Each of these deals exclusively with the species of wood from a particular region or division of the industry, with the information printed in a standardized order throughout the work. A description of the characteristics of the species is included in each group and is followed by the grade-use recommendation, and, after these, the sizes and a brief description of the grade. It deals with 22 individual kinds of soft woods, 33 hard woods, and 26 different broad types of buildings and other structures. Species and grades are recommended, with standard sizes, for framing, joists, sub-flooring, flooring, sheathing, interior trim, exterior wall covering, and, in fact, all the many lumber items required for a building. The manual makes no attempt to influence the choice of the kind of wood; it enables designers and users of lumber to express their own judgment and preferences, in language which is readily understood by the wood-working and lumber trade.

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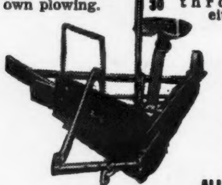
Millions of farmers will do their own — TERRACING —and ALL farmers—including those who benefit by the Government's great projects, will have the responsibility of—***Maintaining their terraces***

Easy to turn. Rolling coulters front and rear. Timken bearings. Does its own plowing.

MODEL 30

All steel. Adjustable for wide or narrow cut. Reversible to throw dirt either way.



Modern terracing cannot be adequately done with plows and home made devices. With—

THE MARTIN
Farm Terracer - Ditcher - Grader

at TODAY'S low prices any farmer is equipped to do his own work when he wishes it done—to make efficient and durable terraces, of most approved engineering standards—in any soil, wet or dry, with animals or tractors.

Martin

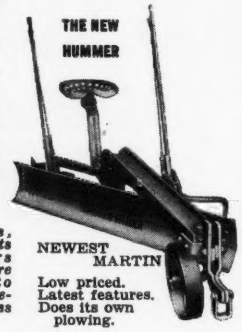
ALL MACHINES SOLD ON 10 DAYS TRIAL
Five Martin Models

Give the farmer a choice for Terracing —Ditching — Road Grading — every dirt-moving job. **For many years MARTINS have been included in county equipment, the country over.**

MARTIN IDEAL

Instantly reversible and adjustable from seat. Sets blade any angle, any height. Strongest steel construction. Lightest draft. Does its own plowing.

THE NEW HUMMER



NEWEST MARTIN

Low priced. Latest features. Does its own plowing.

Engineers, County Agents and others interested are invited to write for details. Address Dept. 30.

Owensboro Ditcher & Grader Co., Inc. - Owensboro, Kentucky, U.S.A.

the BADGE of him who BELONGS

DESPITE the *presumption* it sets up, mere membership in the American Society of Agricultural Engineers is no *proof* of a man's high rank in technical talent. It does prove that he has met certain minimum requirements and has earned the esteem of colleagues who sponsored his application for membership.

But the Society emblem is *evidence* that native talent, be it great or small, is enriched by fraternity with the personalities whose minds fuse to form the pattern of progress in the methods and mechanics of agriculture. The wearer of the emblem waits not for the debut of an idea, but is present at its birth and helps to guide its growth.

Be you novice or veteran, your membership in the organized profession adds something to your efficiency, your vision, your influence as an individual engineer. The Society symbol on your lapel is token that you "belong." Wear it.

ASAE

EMPLOYMENT BULLETIN

An employment service is conducted by the American Society of Agricultural Engineers for the special benefit of its members. Only society members in good standing are privileged to insert notices in the "Men Available" section of this bulletin, and to apply for positions advertised in the "Positions Open" section. Non-members as well as members, seeking men to fill positions, for which members of the Society would be logical candidates, are privileged to insert notices in the "Positions Open" section and to be referred to persons listed in the "Men Available" section. Notices in both the "Men Available" and "Positions Open" sections will be inserted for one month only and will thereafter be discontinued, unless additional insertions are requested.

Men Available

ENGINEER, experienced on extensive mapping projects, drainage projects, construction projects, and the building of railroads in connection with sugar estates, also experienced with sugar mill and heavy construction and with all forms of hoists, etc., desires employment where his experience may be used. Will go anywhere, but prefers the tropical countries. MA-257

AGRICULTURAL ENGINEER desires position in farm structures or utilities field with college or commercial concern. Graduate of Iowa State College. Experienced in farm structures design, in the promotion and sale of building materials, in orchard work and in the manufacture of tractors. Employed at present. Age 26. Married. MA-258

AGRICULTURAL ENGINEER, with technical training and ten years' experience in general farm machinery operating, designing, and troubleshooting, five years' research and experimental work on cotton pickers and cotton harvesters, desires connection with an equipment manufacturing concern interested in adding cotton harvesting machinery to their line. MA-259

AGRICULTURAL AND ELECTRICAL ENGINEER, with bachelor of science degrees in both agricultural engineering and electrical engineering from the University of Wisconsin, desires employment (1) in rural electrification research with a college or experiment station, (2) in commercial work as rural service engineer or distribution engineer with an electric power company, (3) in development and engineering work with a manufacturer developing and building equipment for rural trade, or (4) in the educational field as an instructor or extension worker. Earned all educational expenses while attending college. Reared on a Wisconsin dairy farm. Two-years' experience in federal erosion control camps in Wisconsin in charge of concrete and construction work in erosion and flood control and land utilization. Assisting in instruction work in the agricultural engineering department, University of Wisconsin, at the present time. Location not important. Age 26. MA-260

AGRICULTURAL ENGINEER with bachelor's degree from University of Minnesota, born and reared on grain and dairy farm in southeastern Minnesota, with experience in large-scale farming operation and in artificial hay drying in New York, who knows the propagation, care, and planting of nursery stock and has some experience in erosion control work and in surveying work with the Coast and Geodetic Survey, desires employment for which his training and experience fits him. Age 28. Single. Location not important. MA-261

Positions Open

RURAL SERVICE ENGINEERS needed to fill positions in reorganization of rural electrification department of an electric light and power company. Their duties will be to promote the sale of electrical appliances in the rural areas, negotiate new lines, and work cooperatively with the manufacturers of electrical farm equipment. It is more essential that applicants have a practical knowledge of agriculture than electrical engineering. Salaries at start for these positions will be from $135.00 to $150.00 a month, plus transportation and expenses. Good oportunities for advancement. Write John S. Webb, director, rural sales, Philadelphia Electric Company, West Chester, Pa.

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